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PHOTOGRAPHY IN NATURAL COLOURS.

By H. Snowden Ward, F.R.P.S., *Editor of "The Photogram."*

LIKE the cry of "Wolf! wolf!" raised by the thoughtless shepherd, the announcement that "photography in natural colours" is at last discovered has been so often made that all men who know aught of photography are apt to shake their heads in graver doubt when each new claimant comes. Like "psychic" photography, the photography of colour has been so largely the subject of fraud and misrepresentation that even an honest worker must expect to be met with scepticism—especially when he makes a mystery of his methods, and talk of largely capitalized syndicates is in the air. This is the case with the latest discoverers; and though one of them has succeeded in inducing Sir Henry Trueman Wood and Captain Abney to vouch for the apparent accuracy of his statements, neither of these gentlemen knows the materials employed to produce the effects that have been shown.

In briefly dealing with this subject I am bound to give a few words to its earlier history, but will confine my survey entirely to the direct or purely photographic methods. The indirect or three-colour method, by analysis and subsequent synthesis of the light-colour effects, is well known as a practical and commercial success. The earliest recorded observations of photography in natural colours are of much earlier date than the invention of photography itself, for while the Daguerreotype was not announced until 1839, the principle of direct colour photography was made public by Scheele and Senebier (1777-1782).

These workers discovered that chloride of silver deposited on a smooth surface was darkened by the action of light; but they also went much further, and found that if the light-coloured chloride were exposed to a spectrum of white light the colouring of the silver salt bore considerable resemblance to the colours of the spectrum by which it was produced. From that day to this the selective colouring of silver chloride has been the basis of many attempts to perfect photography in natural colours. Seebeck, of Jena, brought the subject prominently before the public in 1810; while Ritter, Wollaston, (Sir) Humphry Davy, and Thomas Wedgwood, all worked upon and reported their experiments in 1801-2. The four last named applied their energies mainly, if not entirely, to the darkening effect, without regard to colour; but the difficulties were the same in regard to both branches of the subject, and the main difference is that although the fundamental difficulty of "fixing" the image has been overcome in ordinary photography, it has remained insurmountable in the colour work. When once it had been found that silver chloride was changed from (practically) white to (practically) black by the action of light, it was a simple matter to see that by shielding a portion of the surface behind a stencil, a silhouette portrait, or a fern-leaf, a picture of the shield in white upon black, would be obtained. Working with leaves, it would soon be apparent that great delicacy and gradation of the darkening effect was obtainable, for while the ribs and veins of the leaf would be represented by white, its thinner parts were distinctly but faintly tinted. Here was the germ of a very beautiful decorative art, even before the camera method was suggested; but the difficulty remained that if the picture were examined or exposed in daylight the fainter portions at once began to be tinted, until gradually the whole sheet became one colour, and the picture was lost. For a long time no method of preventing this was discovered, but eventually a solvent was found which would attack and dissolve the silver chloride, but which would not affect the salt in the dark state to which it was reduced by the light's action. Hence, after printing under a leaf, the uncoloured silver chloride could be dissolved out and the picture remained as a permanent silhouette.

It might seem as if this method ought to apply to the coloured as fully as to the monochrome image, but this is not found possible in practice. In one case there is a definite chemical change, reducing the silver from the chloride to the metallic state. In the other there is a change too subtle for our present chemical and physical knowledge, so that we cannot expect success by this method until science has progressed considerably. By far the most exhaustive scientific work upon the photo-sensitive salts of silver, especially upon their colours, is that carried on by the late M. Carey Lea, who saw no prospect of success as a result.

To return to the earlier days: Sir John Herschel made reports upon his work in 1819, and in 1841 he expressed before the British Association the opinion that his experiments might lead to the production of naturally coloured photograms. Robert Hunt, working from 1840-43, published his results in 1844, under the title of "Researches on Light." In 1848, Edmond Becquerel produced some exceedingly sensitive silver surfaces, on which he made pictures in colour, not only of the spectrum, but also of natural objects—brightly dressed dolls, etc. This worker is said to have rendered some of his "heliochromes" per-

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manent, but I can find no trace of his having claimed so much; no permanent works are known to exist, and it is known that many of his pictures were very fleeting. Poitevin, in 1868, stated that the coloured image could be "fixed" by means of sulphuric acid; and I believe he gave to the late J. Traill Taylor certain of these coloured pictures, which, "kept in a drawer without any special precautions," retained their colours for (at least) several years. But Mr. Taylor found it impossible to fix similar impressions by any application of sulphuric acid that he could make, and I believe that all other experimenters have been equally unsuccessful.

In March, 1890, Franz Veresc, of Klausenberg, exhibited at the Photographic Institute, Vienna, results on both glass and paper, which were highly praised at the time, and believed to be of great promise. The newspapers of the whole world rang with his fame, but nothing further has been heard on the subject.

The next important announcement, and one that has been fully justified, was made in June, 1891, when Alphonse Berget published, "Photographie des Couleurs par la Méthode interférentielle de M. Lippmann." A preliminary announcement had been made in March of the same year by M. Lippmann himself. The process is totally different, in theory and in practice, from all others, and from the scientific point of view is perfect. It has, however, certain serious practical disadvantages, which I shall shortly mention. The method is based on the "interference" of light waves, and depends upon the idea that if light waves are reflected back along their original path in such a way that they twice pass through a sensitive film, the silver will be deposited in laminæ in the thickness of the film; the distance between the laminæ being governed by the wave-length of the light. Thus, every portion of the film has an arrangement of its silver particles in definitely placed strata, and forms, after development and fixation, a light-filter allowing only light of the same wave-length which deposited the silver to be reflected through it. In practice the sensitive plate is made the front of a trough of mercury, so that the light passing through the film strikes the mercury and is reflected along the same path. The pictures obtained are of great beauty and wonderful fidelity to Nature, the difficulty being that they can only be seen when the plates are held at a certain angle. Practically the most satisfactory way of viewing the results is by casting upon them the light of a powerful optical lantern, which is reflected from the surface of the picture on to a white screen—and this is hardly the method which the general public needs.

As demand always creates a supply of some kind there has been no lack, latterly, of methods, ostensibly more or less simple, for photographing in colours. I must admit that many people who have tried these methods seem unable to obtain any result, yet as they have been read before reputable Continental societies it seems scarce likely that they are mere frauds. A type of several is a paper given before the Société Française de Photographie by M. de Saint-Florent. He takes celloidin (collodio-chloride) paper, exposes it to sunlight until it assumes a reddish-black colour, then soaks it for ten minutes in a bath of—

Alcohol (Beaumé 35°)	...	3 ounces
Glycerine	...	2 drams
Tincture of Iodine (24%)	...	2 drams
Ammonia (·880)	...	6 drops

Dry in dark room, then expose under coloured transparency in direct sunlight for about an hour, when the colours will appear. Fix in a bath of hyposulphite of soda (six per cent. to ten per cent.). In the fixing the colours become brilliant at first, then totally fade to a pale lemon yellow; but if the print is then withdrawn, washed rapidly, and dried in the sun or before a bright fire, the colours will reappear in full brilliancy, and be permanent. One of my correspondents says that this method results in the deposit, in the first bath, and on the paper, of a precipitate of iodide of nitrogen, which is a sufficiently sensitive fulminate to take fire from rubbing with the fingers when the paper is dry.

Another method was given quite recently, before the Académie des Sciences of Paris, by A. Graby. The paper is a lengthy one, complete formulæ are given, and it has the advantage of being mainly based upon suggestions already made by other workers. The whole is given (in a condensed translation) in the *Photogram* for February last, and I cannot well give it in the present limited space. It is based upon work with the various coloured subchlorides of silver, and the author begins by preparing a film in which, simultaneously, we have red and blue subchlorides and a yellow chromate of silver. He says, to quote the translation:—

"Under the influence of blue light the blue subchloride is not sensitive, and remains the same; but the red, if mercuric chloride is present, takes up chlorine and is converted into blue. If chromic acid be present also, the yellow becomes oxidized to blue.

"Under yellow light the chromic acid is not affected, but the blue and red—especially the former—are bleached, losing their chlorine and amalgamating with mercury.

"Under red light the red subchloride remains unchanged, but the blue is changed by the red-orange rays into the red sub-chloride."

Thus we see that each light-ray ignores the pigment of its own colour, and converts to its own colour the pigments that differ. All this, says M. Graby, is old ground; and what he claims as new is a method of removing the old difficulty which caused the whites to be represented by black, and the lighter greys by dark greys, etc., owing to the production of a great amount of pigment under white light. To overcome this difficulty the author uses a gelatine film which, at the outset, is insoluble, but which is rendered soluble by the action of light, the most complete solubility occurring where white light has acted. The print is then "developed" in warm water, as in the carbon process, in which the gelatine is washed away in proportion to its solubility.

Perhaps I have dwelt too long upon these methods, and left too little space for the recently boomed results of Bennetto and Chassagne. In point of time, Bennetto's announcement came a year or more before Chassagne's, and in quality his work is immensely superior. Of Bennetto's method we know nothing. All the pictures he has shown hitherto are transparencies on glass, and he will not allow them to be handled by anyone else, even for the purpose of placing them in the optical lantern. The results are wonderful—as near perfection as we need hope to come.

Chassagne's colour pictures, on the other hand, though wonderful as purely photographic productions, have the appearance of ordinary silver prints tinted with aniline dyes. Of the method we know something. A negative is made, in the ordinary way, on a plate prepared with a "special solution." This is developed in the ordinary way and produces an ordinary negative. From this a print is made on paper prepared with the same "special solution," which gives an ordinary print, which is ordinarily toned and fixed. The print is then immersed, successively, in three baths of dye, when it absorbs each in the portions needing such colour. The manipulations—exposing, developing, and printing—have been carried out by Sir Henry

Wood, Captain Abney, and Herbert Jackson (of King's College), and the results put through the dye baths, immediately and in their presence, by a young lady representing the inventor. The subjects were their own—flowers and fruit bought at Covent Garden immediately before the experiments.

The position of direct natural-colour photography can hardly be said to be finally satisfactory. We have the indirect (three-colour) method, perfect and commercial. We have formulæ published, but insufficiently tested and confirmed. And we have two processes of which the results are shown, but around the methods of which there is a veil of mystery. What has been accomplished gives us hope for success as crowning further work, and I believe that much is yet to be expected from the careful researches of Carey Lea, applied along some such lines as are suggested by Graby.

Since the above was written a patent specification has been filed by Dansac and Chassagne. This, of course, should give us a full insight into the Chassagne process, but, as a matter of fact, it is so complicated, so contradictory, and so chemically impossible that it has been generally accepted as a ridiculous piece of involved phrasing. Even the American agents for the process have acknowledged this, and point out the value of words as a means to conceal thought.

Within the last few days, too, the inventors of the Chassagne process have given three or four demonstrations at the Photographic Convention. In addition to the selective absorption of the dyes by silver prints, the demonstrator claimed that the same action would occur with carbon prints. This, to photographers, seems to finally dispose of any idea of chemical selection. Asked whether the same result could be obtained with a half-tone print (in ordinary printing ink on ordinary paper), the demonstrator offered to try; and though she was stopped before completing the experiment, it went far enough to show that the blue dye coloured the sky, but did not colour a white horse which was the principal object. After this I incline to award the credit to the operator, who paints on the dyes with a set of varying brushes, rather than to any "selective" power of the process.

ANCIENT VOLCANOES OF GREAT BRITAIN.*

VOLCANOES in Britain! How can that be? The volcanoes themselves are dead and buried—buried beneath the cobwebs of antiquity; nevertheless, these ancient lights are unearthed from time to time, like Roman lamps from buried cities, and they tell in eloquent, though silent, terms the story of their infancy, matured life, and old age.

Long, long ago, there was in Great Britain many a truncated conical mountain, topped by cup-shaped hollows communicating with the fiery regions in the interior of the earth. They variegated the scene from the plains below with their dark canopies of blackest smoke and lurid nocturnal gleams of fire. If you possess the happy faculty of imagination it may be possible to infuse new life into the dry bones—raise these old volcanoes from the dead. Drawing aside the curtain which hides the past history of our ancient island home, and in fancy projecting our thoughts backwards to an unrecorded period, one may witness the grinding and hissing murmur of the escaping gases through the dread chasms of the volcanoes of the Malvern Hills; the flashing of hydrogen with thunder-like violence into union with atmospheric oxygen over the Cambrian Group in Wales; the deepening of the blackness as of night rushing upon the realm of noon, encircling the land as with an impenetrable veil—rolling on over air, earth, and sea. Looking towards Charnwood Forest, you may in your mind's eye see the lightnings darting to and fro in innumerable zigzag streaks, woven into a fantastic fiery gauze-like envelope and assuming quaint and vast mimicries of monster shapes striding rapidly across the gloom—the glow of overhanging vapours, like pillars of fire, mingling with the blue flames of hydrogen and sulphur, investing the scene of horrible beauty with hues such as no rainbow ever rivalled. Turning northwards you may behold the volcanoes of the Lake District belching forth showers of ashes mixed with vast fragments of burning stones, and white-hot lava welling over the craters' edges and clothing the mountain slopes with liquid fire—forming in hollows seething lakes. More distant still, the volcanoes of the Cheviot Hills, Ben Nevis, and outwards to the West, in Ireland, by a little stretch of the imagination you may see simultaneous eruptions discharged into the sea.

"The contrast between the peacefulness and beauty of the ordinary landscape and the hideous warfare of the elements at these times of volcanic fury, could not but powerfully impress the imagination and give a colour to early human conceptions of nature and religion. . . . When in later centuries the scientific spirit began to displace the popular and mythological interpretation of natural phenomena, the existence of volcanoes and their extraordinary phenomena offered a fruitful field for speculation and conjecture. . . . By slow degrees the volcano was recognized to be as normal a part of the mechanism of our planet as the rivers that flow on the terrestrial surface. . . . . They feel that their knowledge of the earth extends a little beyond its mere outer skin, and that the mystery which still hangs over the vast interior of the planet can only, if ever, be dispelled by the patient study of these vents of communication between the interior and the surface." Towards the solution of this problem what can the volcanoes of our island contribute? Not a single crater anywhere remains, save where it has been buried under lava. What of the original cones? They have perished, and the most telling evidence of old volcanoes that remains to us is only to be found in the materials which they have left behind. All this scattered evidence of the awe-inspiring objects which once diversified the surface of our land, has been brought together by the

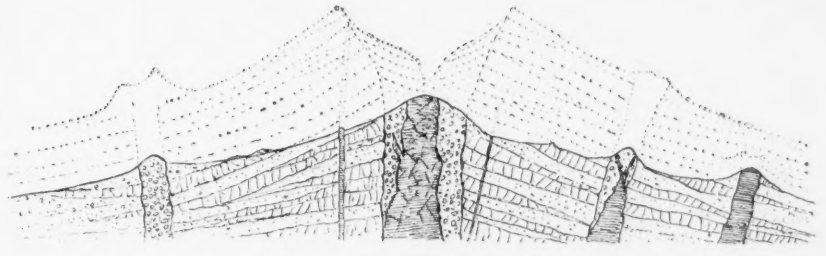

Fig. 1.—Effects of Denudation in a Vesuvian Cone.

* "Ancient Volcanoes of Great Britain." By Sir Archibald Geikie, F.R.S. (Macmillan.) Two vols. 36s.

genius of such men as Sir Archibald Geikie; and their testimony has been supplemented in such wise that the position of long vanished seas, rivers, and lakes may be ascertained. "Popular imagination has long been prone to see signs of volcanic action in the more prominent rocky features of landscape. A bold crag, a deep and precipitous ravine, a chasm in the side of a mountain, have been unhesitatingly set down as proof of volcanic disturbance. Many a cauldron-shaped recess, like the corries of Scotland or the cwms of Wales, has been cited as

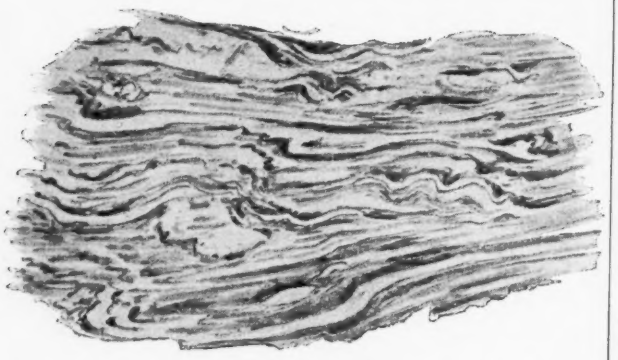

Fig. 2.—Flow Structure in the Lowest Felsite on the Track from Llanberis to the Top of Snowdon.

an actual crater, with its encircling walls still standing complete"; but these are misconceptions which vanish in the light furnished by the relics of the ancient volcanoes of Great Britain.

There is no reason to believe that modern volcanoes differ in any essential respect from those of past ages in the earth's history, and it is possible, therefore, by studying the materials thrown up by the former and comparing them with the ejectamenta and other remains left behind by the latter, to obtain conclusive proofs of the existence of once active volcanoes in this country. In the British Islands ancient volcanoes of the Vesuvian type are well represented. Such a volcano when in activity might appear as outlined in Fig. 1. By prolonged denudation the cone would eventually be worn down, the crater disappearing; and the only relic of the eruptive orifice may be the central lava column (p) solidified within the vent. The waste continuing, it might in course of time reach the original surface of the ground on which the volcano built up its heap of ejected material, the central lava plug being left as an isolated eminence, marking the site of the former vent, as if to commemorate some tragic historical event.

Although all outward traces of actual volcanoes may have been effaced, the erupted materials left in the neighbourhood possess certain characters which distinguish them from other constituents of the terrestrial crust; thus the extrusive rocks are of two kinds—(1) the lavas poured out in a molten condition at the surface, and (2) the fragmental materials, including all kinds of pyroclastic *détritus* discharged from volcanic vents. One can well understand that in such rocks, chemically formed by the reaction of different materials as in a gallipot, the composition will differ in a marked degree from sedimentary rocks, many of which are to a great extent formed by the mechanical mixture of diverse materials. Lavas, however, furnish more easily appreciated characteristics. For example, such a structure of rock undoubtedly took its origin in molten masses from the expansion of imprisoned gases, something after the fashion of yeast in the process of fermentation, and thus forms a crucial test in deciding the once liquid condition of rocks which display it. The vesicles are sometimes flattened owing to elongation of the steamholes by movement of the lava before its consolidation, and by the trend and grouping of these elongated cavities the probable direction of the flow of the lava before it finally came to rest may be determined. The presence of glass, or some result of the devitrification of an original glass, is so abundantly found in lavas that it may safely be inferred that the original condition of most lavas was vitreous. "Not only are vestiges of the original glass recognizable, but the whole progress of devitrification may be followed into a crystalline structure. The primitive crystallites or microlites of different minerals may be seen to have grouped themselves together into more or less perfect crystals, while scattered crystals of earlier consolidation have been partially dissolved in and corroded by the molten glass. These and other characteristics of once fused rocks have to a considerable extent been imitated artificially by MM. Fouqué and Michel Lévy, who have fused the constituent minerals in the proper proportions."

One of the most striking features is the frequency and remarkable flow structure represented in Fig. 2. By making a sufficient number of observations of the direction of this flow and projecting backwards, the point of intersection of all the lines of flow would probably indicate the site of the original vent. "I would," says Sir Archibald, "refer to one of the basement felsites of Snowdon, which forms a line of picturesque crags on the slope facing Llanberis. The layers of variously devitrified matter curl and fold over each other, and have been rolled into balls, or have been broken up and enclosed within the other. The general push indicated by them points to the westward. Turning round from the crags, and looking towards the west, we see before us on the other side of the deep vale of Llyn Cwellyn, at a distance of little more than three miles, the great dome-shaped Mynydd-mawr, which, there is every reason to believe, marks one of the orifices of eruption. It might in this way be practicable to obtain information regarding even

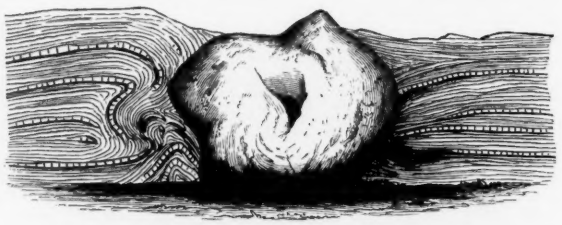

Fig. 3.—Ejected Block of Basalt which has fallen among Carboniferous Shales and Limestones. Shore, Pettycur, Fife.

some of the vents that still lie deeply buried under volcanic or sedimentary rocks."

Among the volcanic records of former periods, one occasionally comes upon a single block of lava embedded among tuffs or even in non-volcanic strata. We know that by the tremendous explosions of volcanoes at the present day such stones are often deflected from the vertical and projected to immense distances from the vent, and there can be little doubt that the blocks of basalt (Fig. 3) found from time to time, were, in the distant past, hurled like thunderbolts from the now extinct volcanoes in our own peaceful island. To those who desire to know more of this fascinating subject, we would say, "Read the

two handsome volumes containing a detailed account of Sir Archibald Geikie's researches in this branch of knowledge." What we have said only conveys a feeble impression of the monumental work this gifted author has bequeathed to scientific literature—a work characterized by an evident desire to tell the truth, the whole truth, and nothing but the truth; a work entirely free from aggressiveness—without the shadow of an attempt to encroach on the credulous by enunciating theories fabricated from "the stuff that dreams are made of." Maps, photographs, drawings, and all that can contribute to give a clear presentment of fact have been called in as auxiliaries, and the total result is indeed gratifying. We must express our indebtedness to the publishers of these volumes for allowing us to reproduce the accompanying illustrations.

J. M.

THE PEDIGREE OF THE CAT.

By R. Lydekker, B.A., F.R.S.

In the article on "The Origin of Some of our Domestic Animals" which appeared in the February issue of this journal, it was stated that want of space precluded any allusion to the ancestry of domestic cats and the various breeds of dogs. And, indeed, to treat adequately of the pedigree of even one of these groups would demand a space at least equal to that contained in a whole number of Knowledge. As this is obviously impossible, all that can be attempted in the present communication is to bring to notice some of the facts and theories bearing on the pedigree of the domestic cat.

Although it is a common notion that our ordinary "tabby" is the direct descendant of the European wild cat (*Felis catus*), now so nearly exterminated in Britain, the best modern authorities are of opinion that the real ancestor is a wild species inhabiting North-Eastern Africa, and commonly known as the Kaffir cat (*Felis Caffra**); a reputed variety of the same species being stated to inhabit parts of Southern Europe. The facility with which several of the smaller species of wild cats will breed together, and likewise the circumstance that the domesticated cats of Asia apparently have an origin distinct from that of the European breeds, renders the subject one of more difficulty than might at first seem to be the case. Moreover, the elaborate investigations lately undertaken by Dr. E. Hamilton into the natural history of the European wild cat tend to show that at least a considerable proportion of the existing representatives of that species have been largely crossed with the domestic race. And it is consequently somewhat difficult to determine what are the distinctive features of the pure-bred wild cat.

With regard to the differences between the domestic and the wild cat, it has been generally asserted that the latter is considerably the larger animal of the two, although the comparisons made by Dr. Hamilton indicate that this is not really the case. The statement that the tail of the wild species is shorter and stouter seems largely due to the circumstance that the fur is more abundant and bushy, so that the tail of the domestic breed appears longer and more slender; but, on the whole, it seems that in domestic cats the tail does differ to a certain extent in this respect from that of the pure-bred wild animal, although, as Dr. Hamilton remarks, individuals of the domestic races are sometimes met with which exhibit scarcely any difference in this respect from the wild cat. Obviously, then, the tail—on which so much stress has been laid—is not a matter of very much importance in the inquiry. With regard to the general coloration of the fur, although both the wild cat and a large number of individuals of the old European domestic breed are of what is commonly known as the "tabby" type, the markings of pure-bred specimens of the former are stated to present certain differences from those of the latter, and are described as being more tiger-like. Then, too, the dark rings on the tail of the wild cat, according to Dr. Hamilton, appear blackish brown when held against the light, whereas those of the domestic "tabby" are jetty black.

Perhaps the most important point in which domestic cats differ from the pure-bred wild cat, and thereby resemble the Kaffir cat, is in the coloration of the hind foot. Dr. A. Nehring, of Berlin, who brought the fact to notice, states that in the Egyptian animal the pads on the under surface of the toes are black, this colour extending upwards on the foot as far as the heel-bone, the under surface of this part of the limb being in some cases wholly black, but in others marked with black stripes on a lighter ground. On the other hand, the pure-bred wild cat has only a small black spot on the pads, while the colour of the fur on the under surface of the foot as far up as the heel-bone is some shade of yellow or yellowish grey. Since all European domesticated cats—except, of course, those which are wholly black or white—agree with the former type of coloration, there seems full justification for regarding them as the descendants of the African Kaffir cat. Moreover, the tail of the latter is distinctly longer and less bushy than that of the wild cat, and thus more like that of the domestic breeds. Additional evidence in favour of the southern origin of our domestic breeds has lately been furnished by Dr. G. Martorelli, of Milan, who has described two European wild cats, the one from Sardinia and the other from the Tuscan Maremma. These are stated to be very different from the ordinary wild cat, and to approximate to the Kaffir cat, of which they are regarded as forming a race or variety, under the name of the Mediterranean cat (*F. Mediterranea*). As these cats present considerable resemblances to domestic breeds, there can be little hesitation in accepting the view that, so far as Europe is concerned, the latter were originally derived from the Kaffir cat.

But Prof. Martorelli goes one step further than this, and suggests that the European wild cat, through the intervention of the Mediterranean race, is likewise descended from the Kaffir cat. Curiously enough, Dr. Hamilton, from the circumstance that certain fossil remains found in Belgium and England seemed to belong to *F. caffra* rather than *F. catus*, had previously hazarded the conjecture "that the European wild cat and the Egyptian domestic cat are derived from one common ancestor."

Although it is going a little out of the way, it may be mentioned here that, in the opinion of Prof. Martorelli, the Kaffir cat has given rise to another line of descendants. The first species on this line is the jungle cat (*F. chaus*) of India and Africa, while the second place is occupied by the various species of lynxes, between which and the Kaffir cat the jungle cat forms a connecting link. From a side branch of this line the steppe cat (*F. caudata*) of Bokhara is considered to have sprung.

Returning to the domestic cat of Europe, it may be mentioned that the animal termed *ailuros* by the ancient Greeks, and kept by them in a domestic state, was not really a cat, although the word is so rendered in our translations of the classics. On the contrary, it appears from the researches of the late Prof. Rolleston, of Oxford, to

* The African cat named *Felis maniculata* does not seem specifically distinct, and *F. caligata* is clearly a synonym.

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have been a species of marten (*Mustela*). That cats were tamed by the ancient Egyptians is proved by the number of their mummified remains entombed in various parts of the country, notably at Bubastis. Indeed, so plentiful are mummified cats that a few years ago they formed a brisk article of trade, being employed for manure. From a careful examination of their remains, it has been inferred by Prof. Virchow that the animal to which they belonged was indistinguishable from the wild Kaffir cat, and was not truly domesticated. In one of the ancient frescoes of the country, there is, however, depicted a cat presenting a striking likeness to the ordinary "tabby," and it is therefore quite possible that a distinct domesticated race may also have existed in ancient Egypt. There is, indeed, a possibility that if the so-called Mediterranean cat be really a wild variety of the Kaffir cat, a domesticated race may have originated in South-Eastern Europe, rather than in North-Eastern Africa. In suggesting that the original domestication took place in the latter area, Dr. Hamilton cites the occurrence of representations of undoubted Egyptian cats in Etrurian tombs dating from a period between 350 and 200 B.C. And a correspondent from Rome writes to him as follows: "I should think there was no doubt whatever that the Etruscans received the domestic cat from the Egyptians by means of the Phœnician traders, as in the very earliest and rudest Etruscan tombs in the neighbourhood of Civeta Castellani (the contents of which are now in the Museum of Papa Guilio, near Rome) there are unmistakable traces of the Phœnician trade." Without denying that such may have been the case, the discovery of the Mediterranean cat, as already mentioned, suggests the possibility of a European origin for the domestic race. On the other hand, the Mediterranean cat itself may prove to be merely a feral race derived from an Egyptian importation.

Be this as it may—and the problem is one hardly capable of decisive solution—Dr. Nehring is of opinion that wild cats were originally brought under subjugation by stationary agricultural tribes, to whom it must have been of the utmost importance that their hoards of grain should be protected as much as possible from the ravages of rats and mice.

When once a domesticated breed had become established in Europe, it would certainly have been freely crossed with the wild cat. And it seems highly probable that to such crossing is due the great prevalence of "tabbies" in Europe previous to the introduction of the now fashionable Persian breed; the wild cat having the dark stripes broader, and frequently more numerous, than they are in the Kaffir cat.

As to the date of introduction of the domestic cat into Britain, the earliest written evidence of its existence there occurs in the laws of the Welsh Prince, Howel Dhu, which were enacted about the middle of the tenth century. Certain remains of cats have, however, been discovered in Roman villas in this country which appear to belong to the domestic breed; and if these be rightly identified, the first introduction of the animal must have been at a much earlier date, the Roman evacuation having taken place about the middle of the fifth century of our era.

Although cats of all colours are now met with, and some of them, at least, have been long known there, the prevalence of "tabby" is, as already said, very characteristic of the old domesticated breed of Europe. In Eastern Asia, on the other hand, as was long since pointed out by that very observant naturalist the late Edward Blyth, "tabbies" are unknown, and either spotted or uniformly coloured cats are prevalent. In India, for instance, where they have not been crossed with a European stock, the ordinary cats are either spotted or fulvous, with barred limbs. In Siam we have the peculiar and valuable Siamese cat, characterized by the uniformly tawny fur of the body, the dark muzzle, and blue eyes. Again, the long-haired Persian or Angora breed is also uniformly coloured, the prevalent tints being white, yellowish, or greyish.

Among the smaller wild species of the genus indigenous to India is the desert cat (*Felis ornata*), of which the general colour is pale sandy, upon which are small roundish black spots on the body, and elongated spots or streaks on the neck and face; two dark bars being present on the inner side of the fore limb. From this species have probably originated the spotted domestic cats of India, in which the spots tend to aggregate into streaks on the fore part of the body, while the slender tail is ringed. Probably, however, considerable crossing has taken place with two other wild Indian species, namely the leopard cat (*F. Bengalensis*) and the tiny rusty-spotted cat (*F. rubiginosa*). Many of these spotted domestic cats have run wild, and one such has been described as a distinct species.

With regard to the fulvous domesticated Indian breed, in which the fur of the body is uniform tawny, the legs barred, and the tail ringed, it seems probable that this, too, was originally descended from the desert cat, but that it has derived its uniform coloration from the jungle cat (*F. chaus*), which, as already said, is related to the lynxes. That it is not the direct descendant of that species seems evident from the different relative lengths of its tail and limbs, and the absence of pencils of hair on the ears.

We have already said that in the opinion of Prof. Martorelli the jungle cat and steppe cat are descendants of the Kaffir cat; and as the desert cat and steppe cat are closely allied, it follows that, if his views be correct, all the Indian domestic cats trace their ultimate origin to the Kaffir cat.

Nothing definite is known as to the origin of the beautiful Siamese cat, but it seems possible that it may be the descendant of the golden or bay cat (*F. Temmincki*) of the Malay countries, which is a uniformly coloured bright ferruginous red or dark brown species, with a relatively short tail.

There is likewise no certain information with regard to the pedigree of the Persian or Angora cat. The deserts of Central Asia are, however, the home of a very peculiar species of the genus *Felis*, which was first described by the Russian naturalist Pallas, under the name of *F. manul*, and is popularly known as Pallas's cat. This species, which is about the size of an average domestic cat, differs from all other wild Old World members of the genus by the great length and softness of its fur. Its general colour is pale whitish grey, with some narrow dark markings on the chest, loins, and limbs; the tail being short and ringed. With the exception of the shortness of the tail and its dark rings, all the characters of this species are just those which might be expected in the ancestor of the Persian breed; and it is quite probable that the points mentioned may have been eliminated by careful selection or crossing.

To discuss certain other less well-known domesticated breeds would probably be wearisome to the reader, and would likewise exceed the limits of our space. Sufficient has been said to indicate that the origin of the animal commonly known as *Felis domestica* is probably a composite one, and that it is scarcely entitled to be called a single species.

If the views of Prof. Martorelli be found substantially correct, the following will be the lines of evolution. Firstly, we have the ancestral type of the Kaffir cat (*F. Caffra*), inhabiting North-Eastern Africa and a considerable part of Europe during the Pleistocene, and perhaps a part of the Pliocene, period. From this original species

originated in the eastern side of the Old World the Mediterranean cat (*F. Mediterranea*) and the wild cat (*F. catus*). When man became dominant he produced the European domestic breed, either directly from the typical Kaffir cat or from its variety the Mediterranean cat. And this original domestic breed soon became crossed with its immediate cousin the wild cat.

On the other hand, in the East the original Kaffir cat gave rise to the jungle cat (*F. chaus*), the steppe cat (*F. caudata*), and presumably, therefore, that near ally of the latter the Indian desert cat (*F. ornata*). From the latter are derived the spotted Indian domestic cats, while the fulvous domestic breed of the same country has been produced by a cross with the jungle cat. Both these are now largely crossed with their somewhat remote cousin the striped domestic cat of Europe.

The Persian cat, as we have seen, may probably be derived from Pallas's cat, which has no sort of connection with the Kaffir cat; and the cross between the Persian and European "tabby," now so common, is consequently a very mixed breed indeed. Finally, it is probable that the Siamese cat has an ancestry totally distinct from that of all the rest.

MILL AND TENNYSON.*

TO the students of Mill, this carefully selected collection of his earlier essays will be most welcome; while the general reader, to whom their author is barely more than a great name, will find in this little volume how wide was the range and how many-sided were the interests that occupied Mill's thoughts. Written for the most part at the outset of his career, these essays breathe throughout the exalted mind combined with a just and genial critical acumen which is so characteristic of Mill in all his work. These were the attributes he brought to bear upon the consideration of the gravest economic problems, as well as to matters with which he was not so closely identified. In his earnest sincerity and thoroughness in all his work will be found the true secret of his marvellous power of comprehension. This principle of thoroughness is of the utmost importance to latter-day students, who are in danger of being carried away by the absurd notion that it is desirable to make haste to do nothing.

The book contains the whole of the five papers comprised in the volume, "Essays on Some Unsettled Questions of Political Economy," which Mill published in 1844, and of which the last, "On the Definition of Political Economy," is now of most interest; one essay on "Corporate and Church Property," which appeared in *The Jurist* in 1833; and the noble eulogy of Carlyle's "French Revolution" which Mill contributed to the *London and Westminster Review* in 1837, "before," as he tells us himself (Autobiography), "the commonplace critics, all whose rules and modes of judgment it set at defiance," had time to sharpen their tomahawks or opportunity to use them. The editor has also reprinted the masterly essay on Bentham which appeared in the same review in 1838; adding as appendices two subsequent articles ("Democracy and Government," and "Remarks on Bentham's Philosophy"), together with Mill's dignified vindication of his father's memory, contained in the well-known letter he addressed to the editor of the *Edinburgh Review*.

It is not by any means the least of our obligations to the author of these essays that he discovered Tennyson for his generation, and the reprint of his original review (now more than sixty years old) of Tennyson's first two volumes of poems will most probably prove to be of more general interest than anything else in the volume. This generous yet critical review of the earlier work of the great poet is indeed interesting reading, and it was a happy inspiration which led Mr. Gibbs to include it in his collection, where it is introduced by two critical papers on "What is Poetry?" and "The Two Kinds of Poetry."

In this edifying discussion, Mill travels lightly over the familiar ground, quoting Ebenezer Elliott's well-known definition of poetry, and contrasting the styles of Wordsworth and of Shelley, to both of whom he pays the highest tribute. But in the essay on Tennyson the essayist is at his best, whether in the kindly act of defending the young poet against the "egregious critic of the *Quarterly*," or in mildly deprecating the "mocking exaggeration" of genial Christopher North. In quoting the whole of the beautiful poem, "New Year's Eve," the sequel of the better known "May Queen," Mill declares it to be "fitted for a more extensive popularity than any other in the two volumes. Simple, genuine pathos, arising out of the situations and feelings common to mankind generally, is, of all poetic beauty, that which can be most universally appreciated"; while the more ambitious "Legend of the Lady of Shalott," "in powers of narrative and scene painting combined, must be ranked among the very first of its class." Mill's discernment and prescience have indeed been amply justified. In the young poet who had so grievously offended the "commonplace" critics (how ludicrous their cavillings now), he could perceive the giant of letters of later years.

We hope Mr. Gibbs may be encouraged to give us a second volume of these fascinating and informing essays, which have been so well selected and so carefully edited.

* "Early Essays by John Stuart Mill." Selected from the Original Sources by J. W. M. Gibbs. (London: George Bell & Sons.) 3s. 6d.

WIND AS AN AID TO FLIGHT.

By F. W. Headley, M.A.

BIRDS understand wind and all its vagaries, and they turn them all to account. Many problems which men of science are compelled to class among those which they hope to solve some day, or, perhaps, despair of solving, a young bird begins to work out directly he is fledged. I will take some typical cases in which a bird derives help from the wind. It will be found that the wind, if it is to lift a bird, supplementing the work of his wings, or even doing all the lifting, must either move in an upward direction, or, if it does not deviate from the horizontal, it must be of unequal velocity. A wind that is unequal, or not uniform, may either be made up of currents moving at unequal rates, or it may blow now gently, now strongly. A uniform horizontal breeze cannot lift or maintain a heavy body in the air unless that body has momentum of its own. It is no better than still air, since the bird—we must try to put ourselves in his position—becomes part of the moving current. The momentum required he derives either from his own wing-beats or from the inequalities of the wind. When a bird rises with wings outspread and motionless, there must be inequality, supposing that the wind is horizontal.

A lark, when he is flying upward—always singing in spite of the steepness of the incline, as if to show how easy it is—invariably faces the wind. When he turns away from it he ceases to rise and generally loses elevation. When he wishes again to rise, he turns his head towards the wind. To take another instance: a cormorant, sated

at last, wishes to join his comrades who are drying their wings on a rock not far off. The wind is blowing towards the rock in question; accordingly he begins by flying in the opposite direction, so that the wind may assist him as he struggles to rise from the water. This feat accomplished, he turns round and makes all sail for his destination. The lark and the cormorant are quite right in thinking that the wind will help to lift them, but it does so only because it increases in velocity as they rise. Near the surface of the land or the sea it is retarded by friction. An anemometer reveals a very marked increase in velocity at successive elevations not far from the ground. By means of kites experiments have been made up to a height of a thousand feet, and even there the increase continues, though it is much more gradual. Were it not for this increase of velocity with altitude, the lark, after his first jump from the ground, would, but for his own efforts, move backward with the wind. It would not lift him any more than it will lift a balloon from which the gas has escaped. But perpetually passing from a slower to a more rapid current (in theory it is convenient to divide the air into definite strata), he has always an inertia which enables the wind to lift him. He is still, so to speak, part of the slowly moving stratum below when he emerges into the rapidly moving stratum above. In fact, he illustrates the principle of the kite—inertia, which is equivalent to momentum, taking the place of the string. As long as the kite is held by the string, it will rise; cut the string, and the wind will at once resign it to the mercies of gravitation. We see, then, that if a lark wishes the wind to help him to rise, he must face it—incline his body forward, as a kite is inclined; and, further, that the inequality of the wind must give him inertia or momentum, or else his wings will have to raise him without assistance. When gulls advance at right angles to the wind without any beating of their wings, the principle applied is the same. From some slight elevation they glide downwards till they are near the ground or the surface of the sea, then (possibly by a twist at the waist) they turn suddenly and face the wind, which lifts them to their former elevation; after which the process begins again.

It may be that when birds soar, *i.e.*, rise in spirals without moving their wings, they are availing themselves at each upward step of the increasing velocity of the wind. But they sometimes attain an elevation of a mile or more, and there the increase must be a negligeable quantity, if it has not at length reached the vanishing point; and, therefore, we have to look elsewhere for an explanation of soaring.

This brings us to the subject of up-currents, obviously much to be desired if wing labour is to be saved; and birds, whenever such assistance is to be had, are always ready to profit by it. When the wind blows against a cliff, it is, of course, deflected upward, and gulls may sometimes be seen enjoying the fun of being lifted like a foam bubble by the up-current, then descending to be lifted again. Oftener they may be seen soaring over cliffs or hills near the shore, ascending in noble spirals without a motion of their wings. The secret lies in the upward slant of the wind. But soaring may be seen under quite different circumstances. The adjutant bird, one of the noblest of soarers, rises till he looks a mere speck or vanishes altogether, over the plains of Burmah. Can there be up-currents there? It is possible that, owing to the ground being unequally heated by the sun, there may be such currents here and there. But in Egypt I have seen kites soaring over fields where the young corn was growing thick and green, and where, consequently, the earth's surface was not much heated. Probably the adjutant depends on the irregularity of the wind. Even what we call a steady wind, we know by Prof. Langley's experiments, is very unsteady, and varies enormously in velocity from one moment to another. This fact the adjutant may make use of, deriving from it the indispensable inertia or momentum. As long as he can offer resistance to the breeze, not being carried by it like a balloon, but feeling it blowing in his face, so long the breeze will continue to lift him. Whenever the wind freshens he will turn and face it, and will rise like a kite. When it slackens he will sail with it, descending slightly. Obviously there will be a good deal of leeway, a phenomenon vouched for by good observers; but there will be a gain in altitude. And thus the grand bird, making even the wind, that "chartered libertine," his slave, rises higher and higher—often, no doubt, watching as he soars for carrion on the earth below, but often, probably, delighting only in the cool upper air, and in the exercise of his own skill.

To descend now to a humbler but very wonderful performance. Gulls may often be seen following in the wake of a steamer without a motion of their wings, though the wind is blowing strong in their faces. They are taking advantage of an up-current. As the steamer advances, the air at the stern rushes down to prevent a vacuum being left, and this down-draught rebounds off the surface of the sea and a strong up-draught is formed. The gull puts himself in this up-draught, which lifts him like a feather-weight, then he glides downward and onward at a great pace. Meanwhile, the point at which the up-draught is formed advances. He soon finds himself in it again, is raised to his former elevation, and the process is repeated.

But often a gull will hover over the stern, apparently almost motionless, in reality steadily advancing with the steamer. Here, too, there must be an up-current, the wind blowing at a slight angle to the steamer being deflected upward when it strikes her side. This buoys the gull up. In rising he loses way; when he advances, he descends. But he does not descend or rise rapidly, as in the case last described. Like a consummate artist, the gull conceals the art which he employs.

For the solution of this and other flight problems more observations are needed. The interest of the subject will amply repay anyone who will devote time and energy to the study of it.

ENGLISH MEDALS.—II.

By G. F. HILL, M.A.

OUR last article* brought us up to the Stuart Restoration in the history of English medals. That event naturally excited great interest, and is illustrated by a number of medals which accord to the King the usual measure of fulsome praise. The most important medallists of this time were the Roettiers, a family of Antwerpian origin, of whom John, the eldest, had been brought to the notice of Charles while residing in Holland. Thomas Simon, who had worked for the Commonwealth, did not retire from his post of Engraver to the Mint until 1664. He died of the plague in 1665, and the fine medal (No. 1) relating to the "Dominion of the Sea," struck in 1665, is supposed to be his last work. The King rides (in the character of Neptune) in triumph over the waves, and the design commemorates the naval victory obtained by the English over the Dutch on the 3rd of June, off Lowestoft.

The work of John Roettier may be illustrated by a medal (No. 2) commemorating the Restoration, although apparently

* *See* KNOWLEDGE for April, 1897.

struck some half-dozen years after. It is chiefly interesting for two reasons: it gives us the type of Britannia since then so familiar, and the lady who sat for Britannia was no other than the notorious Mrs. Stuart, afterwards Duchess of Richmond. Pepys, in his diary (26th February, 1667), mentions his having seen "the King's new medale, where in little there is Mrs. Steward's face as well done as ever I saw anything in my whole life, I think: and a pretty thing it is that he should choose her face to represent Britannia by."

We must pass over the medals struck in the earlier years of the reign of Charles II., such as the "golden medal" of 1662, with portraits of Charles and Catharine; John Roettier's medal commemorating the sea-fight off Lowestoft mentioned on the preceding page; the medals of the plague and fire of 1666; of the Peace of Breda in 1667; of the battle of Solebay in 1672. There are several medals relating to the Popish Plot of 1678, and to the murder of Sir Edmund Berry Godfrey, who was a zealous opponent of the schemes of the Papists. Godfrey, according to the deposition of one of his murderers, was strangled near Somerset House, carried in a sedan chair to Soho Square, and thence on horseback to Primrose Hill. Here they ran his own sword through his body, to suggest suicide, and left him lying in a ditch. No. 3 is a specimen the obverse of which shows a bust of Godfrey, with two hands strangling him with his own cravat. Legend: MORIENDO RESTITVIT REM E. GODFREY. On the reverse are the Pope's and devil's heads joined together, with the legend: ECCLESIA PERVERSA TENET FACIEM DIABOLI —a favourite design and legend on satirical medals in Protestant countries. The defeat of another plot (the Rye House Plot) is commemorated on a medal by George Bower (No. 5); the monster represents the committee of malcontents, the seventh head being that of the devil; the seated figure is meant for the King as Hercules; the wolves which hang from the gibbet on the reverse are Algernon Sidney, Earl of Essex, and Lord W. Russell. The date is 1683. Bower was one of the Engravers to the Mint from the Restoration to 1690.

In the reign of James II. the rebellion of the Duke of Monmouth and the battle of Sedgemoor are, of course, celebrated by a number of medals. But the most interesting pieces are those illustrating the trial of the seven bishops for opposing James's Declaration of Indulgence in 1688. Sancroft, Archbishop of Canterbury, figures on the obverse of the specimen here illustrated (No. 6); on the reverse (not illustrated) are the portraits of the Bishops of St. Asaph, Bath and Wells, Ely, Chichester, Peterborough, and Bristol, arranged round that of Compton, Bishop of London, who had been degraded for showing his opposition to the King in other ways. It is a curious fact that this and other medals relating to the same subject were made by the official Engraver to the Mint. How this could have been permitted during the reign of James it is hard to see; and I would suggest that these medals were made after the flight of the King on the 20th December, 1688. The flight of the young Prince James is satirized on a medal (No. 4) struck in Holland; the Jesuit Father Petre, the King's confessor, is mounted on a lobster,* and holds in his arms the infant Prince. On the Prince's head is a windmill (it will be remembered that the Prince was thought by some to be a suppositious child, and the son of a miller). On the reverse is a satirical coat of arms, with a lobster for badge, and the motto, HONI SOIT QUI NON Y PENSE.

A large series of medals illustrate the history of the Stuarts in exile. The "touch piece" figured here (No. 9) is one given by Henry IX., as he called himself (Prince Henry, Cardinal York, brother of the Younger Pretender). The old ceremony of touching for the "king's evil" included the decoration of the patient with a gold piece, originally an "angel"—afterwards, when that coin went out of circulation, a piece of similar design. On this specimen are the initials of the donor's titles, including that of Bishop of Tuscany, an empty honour conferred upon him by the Pope. The harmless custom of touching is, I believe, still practised by the descendants of the Stuarts; but so far as the constitutional sovereigns of this country are concerned, it was discontinued by George I., who was content to leave this prerogative to the dispossessed house. Dr. Johnson, it will be remembered, was touched by Queen Anne; and the piece which he received on that occasion is in the National Collection.

With the accession of William and Mary the number of commemorative medals begins to increase very largely. In spite of the historic importance of the events commemorated, it is difficult for anyone with any artistic feeling to take an interest in the medals of this time—unless, perhaps, the official medals of the present day serve as a foil. In the reign of William and Mary we may mention a medal of the battle of the Boyne, by R. Arondeaux (No. 7); the King is represented fording the river at the head of his cavalry. The same medallist represented the battle of La Hogue, in which the English and Dutch fleets defeated the French in 1692 (No. 8). The English and Dutch admirals, Russell and Almonde, ride over the sea, one with a trident and broom (to sweep the seas!), the other with sword; in the distance a naval action is going on off Barfleur, and Louis XIII. escapes on a sea shell drawn by frogs. It must be confessed that the humour of the great majority of the medals of this time is somewhat forced.

Fig. 1.—Davison's Nile Medal.

Of the many medals of the next reign relating to the Continental wars, we must mention only a Dutch medal of the battle of Blenheim, with the busts of Prince Eugene and Marlborough on the obverse; on the reverse (No. 10) Marshal Tallard surrendering his sword, while his army is being driven into the Danube. Of civil affairs, the most interesting one that concerns us is, perhaps, the impeachment of Dr. Henry Sacheverell. The present medal (No. 16), which is cast and chased, represents Sacheverell as a supporter of the Papacy. Sacheverell advocated

* The founder of the Jesuit Order dropped his Bible into the sea, and it was restored to him by a lobster!

passive obedience to the authority of princes; and it had been ordered at the time of his condemnation that the decree issued by the University of Oxford on the occasion of the Rye House Plot in 1683, advocating the same doctrine, should be burnt by the common hangman. To this resolution the reverse, with a mitre, and the legend, IS FIRM TO THEE, alludes.

We may pass over the next reign to that of George II. One event of that reign—the taking of Portobello in 1739 by Admiral Vernon—is celebrated by more medals than any other single event in English history, and the number of the medals is no doubt proportioned to the degree of public interest excited.* On the obverse of our specimen (No. 11) is a half-length figure of the Admiral; on the reverse a view of the capture of Portobello: ADMIRAL VERNON TOOK PORTOBELLO | WITH SIX SHIPS ONLY | NOV. 22, 1739. The most satisfactory medal of this reign is, perhaps, the military medal (No. 13) struck to commemorate the defeat of the Younger Pretender at Culloden in 1746. It is by R. Yeo, one of the Assistant Engravers to the Mint. The bust of the Duke of Cumberland, who defeated the Jacobites, is on the obverse; on the reverse Apollo leans on his bow and points at the dragon which his arrow has pierced. The composition, modelling, and setting of this reverse are very much above the average of the time.

There are, of course, a great number of portrait medals, but none of them are distinguished by excellence. That of General Wolfe, the hero of Quebec, is by I. Gosset and J. Kirk (No. 17); the latter medallist is responsible for a large number of medals in this and the following reigns.

FIG. 2.—Reverse of Pistrucci's Waterloo Medal.

The most interesting medals relating to civil affairs in the reign of George III. are, perhaps, those of John Wilkes and of Lord George Gordon. When Wilkes was elected Lord Mayor of London in 1774, a medal (No. 15) was issued celebrating Wilkes's imprisonment for his famous article in the *North Briton*, No. 45, 1763. The jackboot on the reverse is a bad pun on the name of Lord Bute, Prime Minister in that year, while the axe is meant to suggest treason. The medal with the portrait of Lord George Gordon (No. 12) illustrates the "No Popery" Riots of 1779-1780, for which he, as president of the Protestant Association, was responsible. Among other portraits of distinguished men of this reign we may mention (though want of space precludes illustration) one of William Pitt, by Thomas Wyon, jun. Thomas belonged to a large and distinguished family of medallists and seal engravers, one of whom still holds an official position at the present day.

The wars of the close of the last and the beginning of the present century were naturally fertile subjects for contemporary medallists. The Fleming, C. H. Küchler, was employed by one Alexander Davison to strike a well-known medal (Fig. 1 in the text) in commemoration of the victory of the Nile. On the obverse, Britannia holds a medallion with a portrait of Nelson; on the reverse is a view of the two fleets in Aboukir Bay. On the edge is engraved: FROM ALEXR. DAVISON ESQR. ST. JAMES'S SQUARE. A TRIBUTE OF REGARD. Davison presented a specimen of this medal to every officer and seaman who took part in the battle. The present specimen is in gold, in which metal admirals, captains, and commanders received the reward. A somewhat similar medal, by the same artist, was presented by Matthew Boulton TO THE HEROES OF TRAFALGAR.

The battle of Waterloo inspired—if such a term can be used of such a work—a huge medal by the famous Benedetto Pistrucci, who is, however, better known by his design of St. George and the Dragon. This medal measures nearly five and a half inches in diameter. On the obverse, in the centre, are the busts, accollate, of the Prince Regent, the Emperors of Austria and Russia, and the King of Prussia, a singularly unrefined group of heads. Various groups from allegory and mythology are placed around in a kind of broad border. On the reverse (Fig. 2 in the text) the centre is occupied by Wellington and Blucher on horseback, in classical garb, conducted by Victory. The border on this side is a writhing mass of giants, at whom Jupiter, seated on high in a chariot and four, ought to be hurling the thunderbolt which he peacefully holds in his hand. The medal is a peculiarly unconvincing piece of pseudo-classicism, although it is interesting to see that Pistrucci has been studying the recently acquired Elgin marbles for his horses. This medal was never struck, the dies not having been hardened; but it has been reproduced by the electrotyping process. More interesting, perhaps, than this medal, is the small one (No. 18), which was given to all officers and privates present at the battle. The reverse, which is by T. Wyon, sen., is an adaptation from one of the most beautiful coins of Elis; needless to say, most of the beauty has been adapted away. This medal was the first war medal officially issued for general distribution in this century.

* The authors of the "Medallic Illustrations," a work the expression of my obligations to which was accidentally omitted from the preceding article, enumerate forty-seven varieties of medals of this subject alone; while there are many others which allude partly to Portobello, partly to other captures by the popular Admiral. And this list is not quite complete.

ENGLISH MEDALS SINCE 1660

XUM

XUM

There are medals struck by the East India Company, from 1784 onwards, as military decorations; but it was not until 1847 that the services of British troops between the years 1793 and 1814 received official recognition. The "Peninsular medal," by W. Wyon, was then issued (No. 20). The prettiest of the service decorations of this reign is, perhaps, the medal for Arctic discoveries between 1818 and 1855, by L. C. Wyon (No. 14).

From an artistic point of view it is not unjust to say that nothing but second-rate work has been produced from the beginning of this century until comparatively recent years. An attempt has, however, been made to break through the hide-bound traditions of English medallic art. Notably Prof. Legros has produced a remarkable series of plaques in which a study of better models has left its mark; but these portraits are treated in a way which makes it unfair to regard them as medallic. The absence of a reverse is one point of distinction; in the next place the artist has produced something which looks more like a plaster or wax model than a relief in hard material. The result is a vagueness and lack of finish which is pleasing enough in a model in soft material, but irritating in what is supposed to be a completed work which is never to feel the tool again. This style of work is not peculiar to Prof. Legros, but is due to a natural reaction against the lifeless, mechanical style of the Wyons and similar craftsmen. The medal of Lady Julia Grant Duff, designed by the Countess Feodore Gleichen (No. 19), is a praiseworthy attempt at simplicity and reserve, combined with careful workmanship, which has not lost so much as is usual in the mechanical process of production. Other artists have gone straight back to Italian models, without recognizing that the style of the Renaissance is hardly suitable to the present time. But all these are steps in the right direction, and away from the vulgarity of the designs which as yet alone receive encouragement in official quarters.

Science Notes.

The Rt. Hon. A. J. Mundella, M.P., we regret to state, died on the 21st July. Born in 1825, sent to work in a printer's office at the age of ten years, apprenticed two years later to the hosiery trade, and married at nineteen, by the time he was twenty-three years of age he became a partner in the business which was to yield him a fortune. Being self-educated himself, he knew the value of brain power, and a score of years before the existing movement for technical education had begun amongst us he was earnestly advocating the establishment in this country of technical schools. When the movement of the National Education League began, he astonished his townsmen by producing at a meeting an immense number of most carefully prepared and elaborate statistics respecting education in Germany, and the contrasts it presented with the educational condition of England. In recognition of his services to the interests of science and education generally, Mr. Mundella was elected a Fellow of the Royal Society.

On Sunday, 11th July, 1897, Herr Andrée started on his adventurous balloon voyage, by means of which he hopes to achieve the solution of the mystery surrounding the North Pole. The intrepid explorer is accompanied by Dr. Strindberg and by Dr. Fraenkel, the trio having landed at Spitzbergen on the 30th May. The inflation of the balloon began on 18th June, but unfavourable winds prevailed for many days and delayed the start. The direct line from Spitzbergen across the Polar region is some three thousand four hundred kilomètres—about equal to that between Madrid and St. Petersburg—but, as a direct passage cannot be hoped for, the distance Andrée must travel may extend to twenty thousand kilomètres. What the length of time will be in completing this bold scheme can only remain problematical till the adventurers again report themselves, but the supplies of food carried will last about four months. The balloon is of three-fold silk with gutta-percha, and the netting of best Italian hemp. The car, made of basketwork covered with canvas, is some six feet in diameter and four and a half deep. The lower half of it is fitted with baskets for stores of all sorts, and on these there is one bed, the plan being for two of the three men always to be on deck, while the third turns in below for his two hours off duty. While Andrée is admittedly a capable engineer, there are many who regard him only as an amateur in meteorology and Polar research—a mere fabricator of hypotheses: a condition of things which attaches to nearly all abnormal projects—and it will be interesting, therefore, to see whether Andrée can prove himself to be something more than a dreamer of dreams.

A committee, consisting of Lord Crawford, Sir Edward Thompson, Sir Benjamin Stone, Prof. Meldola, Captain Abney, and others, has been appointed for the purpose of forming a National Photographic Record Association, the object of which is to be the collecting and making photographic historical records of the British Isles. The trustees of the British Museum have expressed their willingness to take charge of the proposed collection, as they are of opinion that photographic records for the instruction of present and future generations could not fail to be of the greatest value and interest. We are at one with Sir Benjamin Stone, who, in referring to this scheme, said that word description was rapidly giving way to pictorial illustration, and photography had brought to our aid a more plentiful, graphic, and accurate form of pictorial record than that of the most valuable ancient drawing.

A medal of the highest rarity, and in a beautiful state of preservation, was sold at Christie's recently for £230. It was the Culloden medal in gold, 1746, by Yeo, with bare bust of the Duke of Cumberland to right. Only four or five specimens are known in gold, and this one was given to General Thomas Gage by the Duke at the battle of Culloden, and it remained in that family onwards till recently.

Wireless telegraphy at Spezia by Signor Marconi is reported to have been very successful, the longest distance over which signals were transmitted being fifteen kilomètres.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

STAR SYSTEMS AND THE ICE AGE.

To the Editors of Knowledge.

Sirs,—I find myself involved in controversy to a larger extent than I anticipated, though I have no fault to find with the mode of discussion adopted by either Mr. Backhouse or Mr. Hardy.

As to *physical systems*, the phrase is somewhat ambiguous. Most people borrow their idea of such a system from the solar system, and apply it to a number of bodies whose motions are mainly dependent on each other, and on whom

the influence of extern bodies is comparatively small. In consequence of the law of gravitation, all stars appear to form a physical system in one sense; but within this vast system there are smaller ones like the solar system, or those revealed by clusters and binary stars. But to constitute a system in this latter sense the stars must be mainly influenced by each other, and therefore they must be—like the members of our solar system—nearer to each other than to any other stars, or else their masses must be such that notwithstanding their distances from each other they are the main causes of each other's motions. Now I think when we find stars whose parallaxes, though not accurately known, are certainly very small (and I may add cannot be shown to be approximately equal), situated at considerable angular distances from each other on the sphere, the probability is strongly against their forming a system in this sense. The chances are that, under the law of gravity, some of them are influenced more largely by stars not included in the supposed system than by those that are so. But perhaps Mr. Proctor and Mr. Backhouse do not mean that the stars in Ursa Major form a system in the same sense as the solar system, but rather that they had a common origin. That stars with a common origin may afterwards become detached from each other, and wander as practically independent units through space, seems very probable, and their proper motions may indicate the region of the sky in which they were once found together. But suppose the paths of these five stars which Mr. Backhouse has given in your last issue, were meteor-tracks observed on a night when meteors were as numerous and as variable in direction as the stars whose proper motions are known—could he confidently refer the five meteors to the same radiant, and define its position? I agree with Mr. Backhouse as to the importance of the direction of the motion. Except in the case of a principal star and satellite, I think in order to prove the existence of a physical system the agreement in direction should be very close. But I do not think an agreement in small motions affords the same evidence of physical connection as an agreement in large ones. We might infer with probability a relationship between two men of six feet six who bore a general resemblance to each other, but the probability would be much less in the case of two men of five feet six. There are perhaps one thousand of the latter to one of the former, and when the numbers are great, chance coincidences must occur. Mr. Backhouse's simile of the meteor swarms is hardly apposite. Meteors are so small that they have very little effect on each other's motions—unless they should get into a part of space where there were no large bodies. They keep together because the initial motion and the attracting forces are nearly the same. Two swarms might cross each other almost without disturbance, because the mass of each is very small. But I do not see how two star systems could cross each other without profound disturbance.

Now to turn to Mr. Hardy. I quite concede that Dr. Croll would have proved his case if he had shown that a maximum eccentricity combined with a winter aphelion would produce a permanent icecap at the North Pole—meaning thereby an icecap of a more permanent character and of greater extent than if the eccentricity of the earth's orbit were at all times inappreciable. This is what, in my opinion, he has failed to prove, as completely as the late Mr. J. J. Murphy failed to prove that the effect in question would be produced by a maximum eccentricity combined with a winter *perihelion*.

I almost think Mr. Hardy has inserted the word "not" by inadvertence in the paragraph: "Mr. Monck's argument that the greater heat of a short summer sun would have the effect of melting the snow and ice is *not* borne out by practical observation, as although the Polar sun shines on the Polar snow for six months it has very little effect on it." Surely Mr. Hardy does not regard the Polar summer as an example of the expenditure of a large quantity of heat in a short time, which is the thing that I was dealing with. As to the melting of the Alpine snows, I would ascribe it to the sun, though the water, on being formed from the snow or ice, naturally sinks and makes its appearance below the glacier. I do not believe in any such permanent earth-heat (unless in the case of volcanoes) as would constantly melt the lower stratum of snow or ice without any aid from the sun. But in any event we have not in this case an example of the effect of shortening the time of expending the heat without any diminution in the quantity. I would be disposed to think that the shorter the time the greater would be the melting effect. This might be tested on a small scale by experiment, but I am not aware that the attempt has been made. Divide a block of ice into two equal parts. Expose one to a given number of heat units in an hour and the other to the same number of units in five minutes. In which case will the largest amount of water be produced from the ice? Dr. Croll and Sir Robert Ball might, I think, have tried this instead of arguing it. Use, for example, two lamps, one of which has been found to give twelve times as much heat as the other (though if the chamber was not kept steadily at freezing-point the experiment would not be quite a fair one).

Geologists are not astronomers, but they may discover facts which effectually dispose of astronomical explanations of the phenomena of their science. W. H. S. Monck.

[*No further correspondence on this subject can be published.*—Ed.]

A NATIONAL ASTRONOMICAL MUSEUM.

To the Editors of Knowledge.

Sirs,—Permit me through your columns to call the attention of those interested in scientific education to the desirability of a National Astronomical Museum, with working models, for the purpose of popularizing that science of which the British public are the most ignorant of publics, and of which the merest sketch is given in elementary schools.

English Governments have always had a great objection to undertake the installation of museums for the diffusion of knowledge, or to advance funds to that end; *e.g.*, the foundation of the Hunterian Museum. But the expense of founding such a museum as I suggest would not be great; a small dynamo would work a large number of models, and I am certain that many persons interested in astronomy would subscribe to provide a fund to support such an institution. I have received letters from several of the most distinguished astronomers of England, among others from Sir Robert Ball, promising hearty support.

What we have in this connection in London is valueless to the masses, and nearly unattainable. For example, South Kensington, and also Mr. Ledger's Gresham Lectures crowded within four or five days once a year.

I conceive a free museum open during the day and the evening, Sundays included, where a curator would explain the working models. There should also be an amphitheatre, where—I have reason to know—the most illustrious astronomers would willingly give occasional lectures, illustrated by practical slides. An entrance fee to these lectures is an after question, but the museum must be free—except, perhaps, on students' days. The institution should not be farther from the dwellings of the working classes than the British Museum.

Some years ago I commenced putting my idea into

practice. I constructed sundry rough models worked by hand, purchased lantern slides, maps, telescope, etc.; but everything was destroyed by fire, and I am not at liberty to make a fresh start on those lines.

I think that anyone interested in the subject, and having time at his disposal, should call a public meeting to discuss the idea, the preliminaries, and the practicability; and I think also that the establishment of such an institution would nobly commemorate this auspicious year.

G. E. LAVALETTE, B.Sc.

[I am not quite clear which object Mr. Lavalette has in view—whether he wishes to spread a knowledge of what we may call the popular side of astronomy, or to extend an acquaintance with the details of its progress—necessarily often involving highly technical explanations—or whether he desires to found a school for practical observation. In the last case, he must bear in mind that in any serious sense it is impossible to democratize science, and especially astronomy. Practical observation can only be learnt by practical work in an observatory, and observatories will always be few in number, as they are necessarily costly and great centres of population are the worst possible sites for them. Nor can they ever be available for use by the many, since practically there can be but one observer at each telescope at a time. The British Astronomical Association has in contemplation the erection of a students' observatory in the Regent's Park for the benefit of its members. Should this scheme be carried out, it will probably meet the needs of all those whose circumstances permit them to make serious use of it.

If Mr. Lavalette's idea is rather to promote a knowledge of the details of astronomical progress, this could undoubtedly best be met by a multiplication of lectureships like that so admirably filled by Mr. Ledger at Gresham College. These consist of three series of four lectures each in the year, at the by no means exorbitant cost of £100 per annum. It would, however, be inappropriate to ask the Government to endow a number of such lectureships, but it would be every way advantageous if local bodies were to found them. Lectureships of this order might well be attached to the great free libraries. The analogy of the Gresham Lectures would seem to show that they should be free, and should be designed to give real and serious instruction, and that the expense to the public body supplying them need not be great. I should wish Mr. Lavalette every success if he should endeavour to get this idea adopted. If, however, his idea is first of all to amuse, and mere popular presentments of astronomy are all that he desires, I think we may confidently look to the ordinary caterers for public entertainment to provide as much of this class as the public are ready to take.

The project of a *museum* does not exactly commend itself to me as applicable to astronomy. I fail to see what working models could be supplied except orreries—justly called "foolish toys" by Sir John Herschel, and more misleading than helpful—or models of telescopes which would need explanation from some qualified attendant. Both orreries and telescope models would be far more useful as adjuncts to the lectures.

It is unfortunate that the only point upon which Mr. Lavalette is thoroughly definite is that of Sunday opening—a point which would certainly call forth opposition. But we fancy that an enterprise now successfully at work in the Urania Sternwarte, Berlin, might meet his wishes. Here are four refractors and one reflector on view any fine night at the small fee of sixpence, and from time to time lectures are given in the accompanying theatre illustrated by mechanical and photographic slides, so as to give as perfect a representation as possible of the most striking phenomena which the heavens have to show us.—E. WALTER MAUNDER.]

THE "TEN COMMANDMENTS."

To the Editors of KNOWLEDGE.

SIRS,—A phrase which Mr. George Morley, in his interesting articles on "The Language of Shakespeare's Greenwood," says is "directly conveyed from Shakespeare," is at least older. He quotes from the Second Part of King Henry VI. (Act I., Scene 3) the lines:—

> "Could I come near your beauty with my nails,
> I'd set my ten commandments in your face."

But the expression is to be found in an earlier anonymous play printed in London in 1596, entitled "A Pleasant Conceited Historie, called 'The Taming of a Shrew.' As it was acted by the Right Honorable the Earle of Pembrook his servants." There is a copy of this curious quarto in the British Museum. In this comedy, which differs considerably from Shakespeare's later comedy, Kate is made to say to her boisterous wooer Ferando:—

> "Hands off, I say, and get you from this place;
> Or I will set my ten commandments in your face."

West Hampstead, July 9th, 1897. SILVANUS P. THOMPSON.

SUNDIALS.

Mr. Charles Atkinson, of Tockwith, York, writes asking for information as to how to correctly set a sundial.

[There are several kinds of sundial, and Mr. Atkinson leaves it in doubt as to which kind he wishes to adjust. The horizontal sundial mounted on the top of a short pillar is so much the most common that I will assume it to be the kind in question.

A dial has two parts—the style or rod which casts the shadow, and the engraved dial plate which receives it. The line on the plate bearing the figure XII., marks the meridian. It is from this line that the style rises, and the plane passing through this line and the style must be at right angles to the dial plate. This is the first point to be verified, and an ordinary square will at once show if the style is in adjustment.

The next point is that the dial plate must be truly horizontal. This can be tested by a spirit-level. Thirdly, the style must be inclined to the plate at an angle equal to the latitude of the place; a dial, therefore, is suitable for use only for that special latitude for which it was constructed.

Lastly, the style must be brought into the meridian, and when this is done the style will point to the North Pole of the heavens.

To bring it into the meridian it is necessary to know the time of local apparent noon. This we can ascertain if we have a watch or clock showing the exact Greenwich time, and if we know the longitude of our station and the equation of time. The longitude of York is 4m. 18s. west of Greenwich—that is to say, it is noon at York at 4m. 18s. after twelve at Greenwich. On August 1st, as any almanack will show, the sun is slow by the clock 6m. 5s. Therefore, at 10m. 23s. after noon by a watch keeping precise Greenwich time, the sun will be on the meridian of York on August 1st. At this moment, therefore, the dial plate must be turned until the shadow of the style lies precisely along the central line and points to XII.

It may, perhaps, be well to add that, in the case of a dial engraved for one latitude, it is not sufficient in order to adapt it for another to alter the angle of the style. It is suitable only for the latitude for which it was engraved.

XUM

The difference, however, of a few score miles in latitude will not introduce any appreciable error in the reading of so rough an instrument as a sundial is at best.—E. Walter Maunder.]

Notices of Books.

A Dictionary of Birds. By Alfred Newton, assisted by Hans Gadow; with contributions by R. Lydekker, C. S. Roy, and R. W. Shufeldt. (A. & C. Black.) 30s. net. Illustrated. Prof. Newton is to be sincerely congratulated on bringing this fine work (commenced in 1893) to a successful conclusion. From all the many hundreds of ornithological works which have been published, this book stands clearly differentiated, for it contains in alphabetical order a mass of reliable information on birds of every important genus from every country, and also on all subjects which go to make up the science of ornithology. In an able and lengthy introduction to the work Prof. Newton reviews from the days of Aristotle to the present time the study of ornithology; how it has always been a favourite study; how it has grown from a mere pastime to the dignity of a science, the foundation of which, says the author, was laid by Francis Willoughby and John Ray. From that time onward all the important ornithological works, both at home and abroad, are freely discussed, as are the various methods of classification; and the introduction concludes with grave doubts as to the validity of any systematic arrangement of birds as yet put forth, but with the certain hope that the "end, however distant, will eventually arrive," and we shall have a perfect classification of birds. There is one point in this scholarly introduction which seems to us to mar the whole. Every work of importance is discussed in the text until we come to Mr. Seebohm's "British Birds," which the author considers worthy only of a scathing notice in a footnote. Better far than this to have left the work of that able and enthusiastic ornithologist unnoticed. The dictionary itself is all that can be desired. It is teeming with information, and many of the articles from the various contributors, and especially those on anatomical subjects from Dr. Gadow, are of the greatest value. Altogether, the book is one of the most useful ornithological works ever published.

The Naturalist in Australia. By W. Saville-Kent, F.L.S., F.Z.S. (Chapman & Hall.) Illustrated. £3 3s. In his preface to this sumptuous volume the author says that he has endeavoured to "present to the English reading public a few glimpses of the faunal and floral products of that magnificent component of our empire—the island-continent of Australia." In this object Mr. Saville-Kent has been most successful. The volume is by no means a systematic monograph, nor is it intended to be; but it deals most ably and fully, yet simply, with a number of diversified forms of life that specially attracted the author's attention during the twelve years in which he was engaged in the Fisheries of the Australian colonies. To show the general scope of the work we cannot do better than to enumerate the chapter headings, viz.: Birds, Lizards, Tennites (White Ants), Houtman's Alrolpos, Fishes, Pearls and Pearl-Oysters, Marine Miscellanea, Insect Oddities and Vegetable Vagaries. The subjects with which the author has dealt will thus be seen to be both diversified and of great general interest. Nor does the manner in which this matter is set

Stag's-Horn Coral Growth, *Madrepora hebes*, Great Barrier Reef, Queensland. *W. Saville-Kent, Photo.*
From "The Naturalist in Australia."

forth detract from its popularity, for the author is eminently lucid, and has the knack of putting scientific facts in an intelligible and popular form, our only complaint being that his language is at times unnecessarily pedantic. The illustrations are, however, the feature of the book; they are, in fact, magnificent. The coloured plates, although very fine, are not so successful as the large number of beautiful reproductions of photographs. Mr. Saville-Kent has shown us before, in his "Great Barrier Reef of Australia," what an excellent photographer he is, but the illustrations in his present volume in many cases surpass his former efforts. By the courtesy of the publishers we are enabled here to reproduce two of the smaller ones for the benefit of our readers. One of these represents a North Queensland "laughing jackass," one of the author's numerous pets, "in the act of having killed and snapped up a mouse, whose delicacy of flavour he is anticipating by meditative contemplation, preparatory to swallowing it whole." This bird is not the true "laughing jackass" (*D. gigas*) so well known to visitors at the Zoological Gardens. Indeed, Mr. Saville-Kent is inclined to think its name somewhat inappropriate, since "it can scarcely be said to laugh, and its 'smile' at close quarters is so loud and ear-piercing that unsympathetic neighbours most uncharitably defined it as a compromise between the shriek of a locomotive engine and a policeman's rattle." The other photograph is of part of a tidally exposed reef of a Madrepora coral. In the photograph we can only get an idea of the beautiful shapes of this coral, but we cannot imagine, even from the author's able description, the magnificent spectacle which this coral affords in its natural colours of various shades of brilliant green, lilac, and brown. Nor can we form any idea of the colour of corals from specimens in museums and elsewhere, for the colour fades when the insect dies. Altogether, this is a most interesting and instructive book, and one which cannot fail to interest a lay reader from beginning to end. In addition to its general interest, it contains a great deal of valuable and original information for specialists, and is often suggestive of new or indifferently worked fields for further observation and study.

W. Saville-Kent, Photo.

North Queensland "Laughing Jackass" (*Dacelo Leachii*).
From "The Naturalist in Australia."

Birds of our Islands. By F. A. Fulcher. (Melrose.) Illustrated. This book deserves a lengthy review, not for any value attaching to it, but in order that attention may be directed to the numerous glaring errors which it contains; and this is the more important inasmuch as it has been favourably reviewed, we grieve to state, in several of our contemporaries. *The Zoologist*, for instance, considers it "an excellent book to put in the hands of a bird-loving boy or girl"; and *Nature* thinks much the same. We would rather say, "Let the ornithologist read it, for it will amuse him, but at all risks keep it out of the hands of the uninitiated." The first ridiculous error which strikes one on opening the book is the labelling of a beautiful drawing by Mr. Thorburn of a peregrine falcon and a wild duck as a "Merlin and its Prey" (page 241). Then we have an illustration of some young gallinaceous birds called by the authoress "larks" (page 15), and a very bad drawing of a green woodpecker called the "great spotted woodpecker" (page 109), while a couple of whimbrels, on page 199, are labelled "curlews." The illustrations are mostly second-hand — some are very good and well known, but others are mere caricatures. There is a good deal to be said against illustrating a book with drawings which have appeared in other volumes, but when this privilege is abused by calling the drawings by wrong names the practice becomes unbearable. Turning to the text, we might fill columns in pointing out its inaccuracies and misstatements. Suffice to draw attention to a few of these only. We are told that the swift is one of the *Hirundinæ* or swallows, and that the "gannet is the whitest member of the family of geese." Surely before one starts out to teach, one should know at all events the A B C of the subject. Had Miss Fulcher studied any standard book on birds before posing as instructor of the young, she would have learnt that the swifts do not belong to the swallow tribe, but to the order *Picariæ* (woodpeckers, cuckoos, etc.), and that gannets bear no relation whatever to geese, but are of the same family as the cormorants, the *Pelecanidæ*. Again, we are told that "the little auk, when on rare occasions it visits our shores in the winter, comes in a dress of white feathers only speckled with brown, with leggings of

bright yellow." We have never seen a little auk in this curious plumage. The winter plumage of the little auk is a brilliant black above, save for a few white streaks on the scapulars, and white underneath; and if "leggings" imply legs, the colour of these in the little auk could by no stretch of an ordinary imagination be called bright yellow. The stormy petrel is not known to breed in England east of Lundy Island (to ornithologists, at all events), but we are told by the authoress of this book that the bird is found all round our coasts in the breeding season. Beyond inaccuracies, a number of statements, which no ornithologist could verify, are put down as positive facts. This is a book written to teach young people, and as such it should before all things be accurate in every particular. The only safeguard against such books is in the criticism of the press; but when a book like this has been favourably reviewed in journals which are acknowledged authorities in science, what can we suggest but that there should be a law to recall and destroy such productions as the one before us, and that some such means as those adopted in the Merchandise Marks Act should be devised for branding all future goods from the same market?

Higher Mathematics. Edited by Prof. Mansfield Merriman and Prof. Robert S. Woodward. (New York: Wiley & Son. London: Chapman & Hall.) 21s. net. This is the best text-book of higher mathematics that we have seen for a long time; and it is suitable alike for classical and engineering colleges. From the bewildering mass of mathematical knowledge now existing, the essentials have been extracted, and in the present volume they are brought together, added to them being numerous problems for solution and examples of the application of theory to physical science. There are eleven chapters, each by a different author, and the subjects of them are: the solution of equations; determinants; projective geometry; hyperbolic functions; harmonic functions; functions of a complex variable; differential equations; Grassmann's space analysis; vector analysis and quaternions; probability and theory of errors; history of modern mathematics. This list is sufficient to convey to students of mathematics an idea of the extreme value of the work, the only noteworthy omission being a chapter on elliptic integrals and functions. The editors recognize that such a chapter is required to complete their collection, but it was found impracticable to obtain the manuscript of it in time for publication. However, armed with this volume, students and teachers will be able to put themselves in touch with the essence of mathematical knowledge. They will find therein the best methods of attacking problems covering a wide range in mathematics and mathematical physics, and will easily discover how to arrive at solutions of equations to satisfy almost any conditions. The whole work is so well done that it would be creating an unnecessary, as well as an invidious, distinction to single any particular sections of it for praise. Suffice it to say that each section has been entrusted to a distinguished American professor of mathematics, mechanics, or engineering, and that some of the subjects—for example, that on Grassmann's space analysis—contain the substance of very rare treatises. Only students of higher mathematics can give full appreciation to this admirable and serviceable work; but they will award it a prominent place in their bookshelves.

Physiography for Beginners. By A. T. Simmons, B.Sc. (Macmillan.) Illustrated. 2s. 6d. An introduction to the sciences, such as the one under notice, has long been a desideratum. So far as we know, the subject has not heretofore been adequately treated as regards the experimental illustration of the text. Mr. Simmons, taking advantage of the opportunity presented by the issue of a new syllabus by the Science and Art Department, has with admirable courage faced the by no means easy task of bringing together numerous suggestions for experiments which may readily be performed by teachers with the slightest pretensions to familiarity with manipulative efficiency. There can, therefore, be no further excuse for those preceptors who content themselves with telling the students to read about the instructions and exercise their imagination! The literary element also is not of the stereotyped character so familiar in such books, but a free and untrammelled diction pervades the whole, which can only be expected from one who has a thorough knowledge of the theme.

Metals. By A. K. Huntington and W. G. McMillan. (Longmans.) Illustrated. 7s. 6d. "Bloxam's Metals" was formerly a book known to most students of metallurgy, but, like Pat's knife which had had three new blades and two new handles, it has been so transformed by emendations and additions, to keep pace with the innovations of the metallurgical arts and industries, that it may be almost regarded as a new work—the task of revision, Prof. Huntington assures us, having been more difficult than writing a new book. However this may be, the late Prof. Bloxam's name is removed from the title page and is but barely mentioned in the preface. There is, nevertheless, still enough in the general disposition of material to remind one, by association, of the original author, and we cannot suppress a feeling of regret that publishers should practically assign to oblivion authors whose names have long been an inspiration. The work was originally a very good one for its purpose, and in its present aspect it is still well adapted for the student, by the sustaining power which Prof. Huntington and Mr. McMillan have imparted to it.

The Genesis and Matrix of the Diamond. By Henry Carvill Lewis. (Longmans.) Illustrated. 7s. 6d. The philosopher Steffans is accredited with the dictum:—"Diamond is quartz which has arrived at self-consciousness!" And an eminent geologist has parodied this metaphysical definition thus:—"Quartz is diamond which has become insane!" As a matter of fact the diamond is one of the riddles of nature—a perennial puzzle. What it is, chemically, we do know; but how in nature's laboratory it became what it is, still remains a mystery. It would appear that the late Mr. Lewis was a firm believer in the volcanic origin of diamonds, and that the diamonds belong to and are part of the matrix in which they lie. This view is supported by many facts gleaned from much careful study of the diamond-bearing pipes in the Kimberley mines. Side by side with this theory there is, however, still some room for the meteoric theory of the origin of the diamond. The splendid mineralogical dissection of the matrix, and the suggestive sidelights cast by Mr. Lewis on the genesis, invest the work with real intrinsic value, and the many references to the titles of similar works by other writers contribute largely to its worth. The editing has been done with that literary skill which characterizes all Prof. Bonney's work.

SHORT NOTICE.

Italian Highways. By E. Augusta King. (Bentley.) Those fireside travellers who see foreign lands only through the eyes of others, and who themselves have never traversed the Italian highways, will find here a most entertaining cicerone—a guide full of all kinds of information, culled from the best writers of all the ages, and projected like sunshine on all manner of objects indiscriminately, from a statue of Dante and the gods of Olympus, to the vine-destroying insects.

BOOKS RECEIVED.

Reform of Chemical and Physical Calculations. By C. J. T. Hanssen, C.E. (Spon.) Illustrated.

Electricity and Magnetism for Beginners. By F. W. Sanderson, M.A. (Macmillan.) Illustrated. 2s. 6d.

The New Century Review. (The Unicorn Press.) 6d. net.

All About Animals.—Part II. To be completed in twelve fortnightly parts. (Newnes.) 6d. Illustrated.

A Primer of French Etymology. By B. Daly Cocking. (Innes & Co.) 1s. 6d.

Creation, with Development or Evolution. By J. Dudley R. Hewitt. (Kegan Paul.) Illustrated. 6s.

Aluminium. By A. G. Brown. (Aluminium Supply Company.) Illustrated.

British Marine Food Fishes. By Wm. C. McIntosh and Arthur T. Masterman. (Cambridge University Press.) Illustrated. 21s.

Bureau of Ethnology. Fourteenth Annual Report to the Secretary, Smithsonian Institution, 1892-3. By J. W. Powell. (Government Printing Office, Washington.)

Souvenir of Madame Sans-Gêne. By Victorien Sardou and Emile Moreau. (G. Bell & Sons.) Illustrated. 1s.

The Ascent of Man. By Prof. Drummond. (Hodder & Stoughton.) 3s. 6d. New edition.

ASTRONOMICAL PHOTOGRAPHY.—I.

THE CONDITIONS WHICH DETERMINE THE LIMITING TIME OF EXPOSURE.

By F. L. O. WADSWORTH,

Astrophysicist, Yerkes Observatory.

IN the April Number of KNOWLEDGE there is a paper by Dr. Roberts describing one of his fine photographs of the Orion nebula, taken with an exposure of seven hours thirty-five minutes, which "depicts, very probably, the maximum of extent and detail that can be shown by aid of photographic methods." This statement, as Dr. Roberts points out, is a most important one; "for, if correct, it proves that, as regards duration of exposure, we have already reached the limit of the available aid by this method in astronomical researches." The reasons upon which this conclusion is based are: "(1) The film of the negative is, in consequence of prolonged exposure to the latent sky luminosity, darkened on development to a degree that would obscure faint nebulosity and faint stars. (2) Longer exposures of the plates would not reveal additional details of nebulosity nor more faint star images."

In spite of the well-known skill and long experience of Dr. Roberts in this line of work, and the consequent great weight of his opinion on such a subject, the point involved is too important a one to allow it to pass without question. Dr. Roberts has recognized that objections will be raised to his conclusions, and has endeavoured to answer some of them in advance. But there is one point of great importance, which, strangely enough, seems to have escaped the attention, not only of Dr. Roberts, but of all other writers on the general subject of astronomical photography (among others, Angot, 1877; Grubb, 1887; Tennant, 1888; Schaeberle, Turner, 1889; Christie, Charlier, 1891; Harkness, 1892; Abney, Searle, 1893; Newall, Pickering, 1894; etc., etc.) whose papers are accessible to the writer.

Reference is made to the influence of the aperture of the photographic instrument upon the brightness of the field due to the general illumination of the sky. This general illumination is produced by scattering of light in our own atmosphere, by small particles (Rayleigh), and varies in intensity inversely as the fourth power of the wave-length. It is therefore of a character which affects a photographic plate much more strongly than it does the eye. Moreover, the great majority of the diffracting particles being at a relatively great distance from the instrument, the illumination is of the same character *as would be produced by a uniformly luminous* area of infinite extent.* Now it follows at once from the principle of the wave theory that *the intensity of illumination at the focal plane of an objective due to such an illuminated area will be simply proportional to the area of the objective—i.e.*, to the square of the linear aperture (b); *and will be entirely independent of the focal length* (f) *of the instrument. Hence, for a given brightness of sky* (k) (dependent upon the altitude of the observing station and upon the condition of the atmosphere), *the time of exposure requisite to produce a given fogging or blackening of the plate will*, other things being equal, *vary inversely as the square of the linear aperture of the image-forming lens, no matter what the focal length of the latter may be.*

In referring to the long-exposure photographs taken by Dr. Gill at Cape Town (twenty-four hours fifty-three minutes, on Eta Argus), and by Dr. Wolf, Dr. Roberts says: "The reason why a refractor of focal distance to aperture in the ratio of one to ten could not cause the darkening of the film . . . . so rapidly as a reflector of the focal ratio of one to five, is consequent upon the greater power of the latter in the concentration of light upon the sensitive film than is possessed by the refractor; there is also loss of light by reflection from the surfaces of the lenses by absorption, and by absence of perfect achromatism in the lenses. Less sensitive plates may also have been used in the refractor than were used in the reflector, and the development of the plates may not have been carried or the same degree of intensity. Therefore, on consideration of all the relative conditions, twenty-five hours' exposure of a plate in the refractor may not be so near the limit of practical photographic effect as seven and a half hours would be with the twenty-inch reflector." From the preceding consideration it will readily be seen that this explanation is not the true one. The fundamental cause of the difference in exposure possible with the two instruments under consideration lies in the difference in linear aperture. I assume (not having been able to find the paper of Dr. Gill describing the plate in question) that the photograph of Eta Argus referred to was taken with the standard instrument prescribed by the Astrophotographic Congress, which has a linear aperture of thirteen inches, and a ratio of aperture to focal length of nearly one to ten. If all the important conditions, save that of size of instrument, which affect the general blackening or fogging of the film—*i.e.*, the brightness of the sky, the efficiency of the objective as regards optical form, transmitting (or reflecting) power, etc., the sensitiveness of the film, the manner and extent of development, etc., etc.—were the *same* in the two cases, the instrument of thirteen inches aperture would permit of an exposure nearly two and one-half times as long as the one of twenty inches aperture. If, then, we consider seven and one-half hours (more exactly, seven hours thirty-five minutes) as the limiting time of exposure for Dr. Roberts' instrument, the limiting exposure for a thirteen-inch under the same conditions would be nearly nineteen hours, and for a six-inch at least eighty hours.

This, however, is not the most important conclusion to be drawn from this relation between brightness of focal field and aperture. The mere ability to lengthen the time of exposure (at least beyond twenty-four hours) by decreasing the size of the photographic objective would not, in itself, be of great importance, because there would be

* Owing to the greater thickness of atmosphere traversed by the light coming from the stars (and other luminous celestial bodies) near the horizon, the general illumination of this portion of the sky will be somewhat greater than of that portion near the zenith.

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too much risk and difficulty in accurately following an object for a much greater length of time than is done at present. But in the case of nebulæ, planets, and other celestial bodies (or phenomena) of finite though limited size (*i.e.*, of size less than the field of the camera), the intensity of the image at the focal plane varies, as is well known, as the square of the angular aperture of the objective—*i.e.*, as $\left(\frac{b}{f}\right)^2$. Since the intensity of the field (due to the sky) varies, as already shown, as b^2 only, it at once follows that for two instruments of the same ratio, $\frac{b}{f}$, of aperture to focal length, but of different linear apertures, b_1 and b_2, the *contrast* between object and field will vary inversely as $\left(\frac{b_1}{b_2}\right)^2$; or an objective of one inch aperture and (say) five inches focal length, will photographically reveal details only one-fourth as bright, as compared with the sky, as can be revealed by one of two inches aperture and ten inches focus. *Or, assuming that the development of the plate can be pushed by proper methods correspondingly farther, the first lens will record given details in one-fourth the time required by the second.* In comparing the rapidity of two lenses of differing aperture and focal length, it has heretofore been customary to consider the exposure time for a given object to vary simply as the intensity of the image at the focal plane, *i.e.*, as the square of the angular aperture. Anyone who has tried photographing an object against a bright extended background, such as the sky, knows that this law fails signally. Prof. Barnard, in his experiments with the "lantern lens" at the Lick Observatory,* found that for very faint objects, like the extended portions of the Orion nebula, the Andromeda nebula, the earth-lit portion of the new moon, etc., the time of exposure required with the "lantern lens" was only one-twentieth to one-fortieth that required with the Willard lens. The latter had an angular aperture of one-fifth; the former an angular aperture of about two-sevenths. Hence, according to the usual rule, the time of exposure required for the lantern lens would be a little less than one-half that required by the Willard lens, or from ten to twenty times what was actually required.† This difference is very much greater than can be possibly explained by any difference in the construction or transmissive power of the two lenses, and proves conclusively that it is a question of *contrast between image and field*, rather than of absolute intensity of *image alone*, that determines the time of exposure necessary to record photographically given details of any object of finite angular extent. If we compare the "lantern" and Willard lenses on this basis, we find that there is no discrepancy remaining to be explained. For the aperture of the Willard lens was six inches, while that of the other was one and a half inches. Hence the squares of the relative angular apertures being, as already stated, about one to two, the ratio of the *contrast* between object and field would be in the two cases—

$$\frac{\text{Lantern}}{\text{Willard}} = \frac{2}{1} \cdot \left(\frac{6}{1{\cdot}5}\right)^2 \simeq \frac{32}{1}$$

a value which agrees with the experimental results of Prof. Barnard already referred to. Further evidence of the correctness of this method of comparison is furnished by the results of Pickering in photographing the Orion nebula. Pickering used a Voightländer portrait lens of 2·6 inches aperture and 8·6 inches equivalent focus, or of about $\frac{1}{3{\cdot}3}$ angular aperture.‡ This is almost exactly the angular aperture of the "lantern lens" ($\frac{1}{3{\cdot}5}$), and, according to usual law, the time of exposure for a given object ought to be the same for the two lenses (about eleven per cent. less for the Voightländer lens). But the time of exposure required for the Voightländer lens was three hours, while that required for the "lantern lens" was only one hour fifteen minutes—about five to twelve as long. The ratio of *contrast* for these two lenses is—

$$\frac{\text{Lantern}}{\text{Voightländer}} = \left(\frac{3{\cdot}3}{3{\cdot}5}\right)^2 \cdot \left(\frac{2{\cdot}6}{1{\cdot}5}\right)^2 \simeq \frac{13}{5} \text{ instead of } \frac{12}{5}.$$

Here, again, the agreement between the ratio of theoretical exposures and the ratio of actual exposures is very close. It is, in fact, even closer than appears, because Pickering's photograph with three hours' exposure did not show quite as much as that of Barnard with one hour fifteen minutes' exposure.

This law of variation of the brightness of the field according to the inverse square of the aperture of the camera objective, is also of great importance in indicating the proper instruments for use in various fields of research in astronomical photography. It will be quite evident from the preceding considerations that the instrument best suited for the photography of any faint extended celestial body or phenomena, such as nebulæ, comets, meteor trails, the gegenschein, the zodiacal belt, etc., is one of very small linear aperture—smaller even than any that have so far been used. It should, of course, also have as large an angular aperture (ratio of aperture to focal length) as possible; but this will be determined to a certain extent by the angular extent of field sought after, by the scale desired, and, in the superior limit, by optical difficulties of construction. Because of these last an angular aperture greater than one-fourth is hardly practicable when any extent of field is to be covered at all sharply, and it is better not to go below a ratio of one to five. So far as I know, the smallest lens which has been used in astronomical photography is the "lantern lens" of Prof. Barnard already referred to, having a linear aperture of one and a half inches. But I believe very much smaller apertures than this even may be employed to advantage; and I have recently proposed to make use of two Zeiss microscope objectives (for microphotography), having apertures of only 0·28 and 0·42 inch respectively, for photographing certain very faint objects, particularly the gegenschein and the fainter portions of the zodiacal band, and for searching for faint nebulosity in portions of the sky in which it has not previously been detected. These lenses, which have an angular aperture of one to five—the same as the Willard lens—would be respectively about four hundred and fifty and two hundred times as efficient as the latter (granting that they are as good from an optical point of view), either as regards time of exposure (supposing the development can be pushed far enough without fogging the plate by the action of the developer itself) or as regards extent of detail, which can be obtained with long exposures (granting that the scale of the photograph is sufficient to show this detail).

The difficulty mentioned in the last sentence of the preceding paragraph is perhaps the most serious objection to the use of very small apertures. Unfortunately, there is no way of avoiding it, for looking at the relation between intensity of image and of field in another way, we see that the *contrast* between the two depends ultimately simply on the absolute focal length (f).* To obtain four times the

* *Astronomy and Astrophysics*, December, 1894, p. 811.

† It was Prof. Barnard's calling my attention to this great discrepancy which first led me to investigate this problem.

‡ *Sid. Mess.*, Vol. IX., p. 2, January, 1890.

* Intensity of image varies as $\frac{b^2}{f^2}$; intensity of field as b^2 ∴ contrast $= \frac{\text{image}}{\text{field}} = \frac{1}{f^2}$.

contrast we must decrease the scale of the resultant photograph one half; to obtain nine times the contrast, two-thirds; and so on. It is therefore important to note that the full advantages of using a small linear aperture (and corresponding small focal length) will only be realized when the objects photographed are large enough to stand the necessary reduction in size without danger of losing detail by reason of the finite size of the silver grains in the photographic plate. This objection has, however, no weight as regards the value of such small instruments in searching for new nebulosities so faint as to have entirely escaped previous notice. The important thing in such a case is to first find the nebulosity at all; the problem of observing or photographing it in detail will come later.

Another important conclusion follows at once from the considerations of the preceding paragraph. *For a given absolute focal length* (say thirty inches, as in the Willard lens), and hence for a given scale on the photograph, *the efficiency* (considered in the same sense as before, either as regards exposure time for a given detail, or detail obtainable with a given exposure time) *of the objective, other things being equal, is entirely independent of its linear, and therefore of its angular, aperture.* In other words, a telescope of one inch aperture and thirty inches focal length would photograph a given nebula just as quickly and in just as much detail as the Willard lens of six inches aperture. This conclusion is at first sight sufficiently startling, but it may at once be seen to be true by remembering that while the intensity of the image diminishes as the square of the aperture, the brightness of field diminishes in the same proportion; and the *contrast* between the two, which has already been shown to be the principal if not the only factor in determining the time of exposure and the detail on the photograph, remains unaltered. Of course this conclusion only holds, as has already been pointed out, provided the development of the plate can be controlled so as to bring out a given *contrast*, whatever be the absolute intensity of action. In general, the less the absolute intensity of the image and field, and hence the feebler the action on the plate, the longer the development required, and the greater the tendency to fog the plate in the development itself. Besides, if pushed to the extreme, the image might become so faint as to be incapable of affecting the sensitive film at all. The results of Barnard, already quoted, have shown that the development may be controlled over times of exposure varying from one to about forty, and corresponding to light action (intensity × time) varying from one to twenty. It is a question for actual experiment as to whether the process of development cannot be controlled over a much wider range of light action; the results obtained by the careful development of an ordinary negative, in which it is possible to obtain at the same time detail in both the high lights and the shadows, seeming to indicate that it could. We may at least consider that the above comparison between the one-inch and six-inch lens, in which the light action for a given time of exposure will be in the ratio of one to thirty-six, is justified by the results already obtained. Granting that it is,* it is readily seen that the instrument of smaller aperture (given focal length) has for the purposes already considered the following advantages:—

1. For a given form of objective the field can be made flatter.

2. For the same field, a single achromatic objective might be used instead of the photographic doublet.

3. The whole instrument, including mounting, is very much lighter and cheaper.

4. The full resolving power of the instrument may be photographically utilized.*

If our purpose is to depict most clearly the object alone—*i.e.*, free from the stars around it and superposed upon it—the instrument of small aperture has the further very important advantage of showing in a given time of exposure very many less stars than the one of larger aperture would do.† For the intensity of a star image varies as the *fourth power of the aperture*, while that of the nebula or other *extended object varies only as the square.*

(*To be continued.*)

* It will be noticed that this question does not arise in case the angular aperture remains constant. For in that case the intensity of the image also remains constant for all linear apertures.

THE METAMORPHOSIS OF A DRAGON FLY.

By Rev. A. EAST.

IF the lower jaw be a sign of strength of character, the dragon fly (*Libellula*), in its larval state, must be of an exceptionally resolute disposition, for the lower jaw or mask is no less than three times as long as the head, and is furnished at the end with a kind of horny split lip and a pair of very serviceable nippers. The lower jaw measures half an inch, and the whole head a trifle over a third of this length. No ordinary arrangement could possibly adapt such a jaw to its head, and if anyone will try resting the chin in the palm of the hand, and extending the thumb and little finger, he will have a very fair notion of this terrible jaw—the thumb and little finger representing the nippers of the jaw, and the whole arm representing the jaw or mask (Fig. 1). This mask, in fact, is jointed in the middle with a kind of elbow, and, when not extended (Fig. 2) for the purpose of seizing prey, extends downwards from the lingua, to which it is attached, as far as the second pair of legs, and then up again to meet the maxillæ; the edges of the mask, when so folded up, fitting closely against each other, and forming altogether what looks like an enormous chin (Fig. 2).

The action of protruding and withdrawing the mask with lightning rapidity is very much like that of the tongue of the frog; but it must be confessed that our friend is not so good a sportsman, for he as often as not aims short in his eagerness and misses his mark, but the more phlegmatic frog never misses.

It is difficult at first to see how the larva progresses through the water, for he has no feathered legs for swimming, nor does he use his legs for this purpose. As a rule he creeps slowly and stealthily along the bottom, or rests immovable with the body pressed closely against an upright stem, or stands on tip-toe with chin on high, expectantly waiting for what fortune may send him; but he can, when alarmed, shoot through the water with the speed and straightness of a torpedo-boat, and without any

* I have already shown that in order to photographically utilize the full resolving power of an objective, the ratio of aperture to focal length $(\frac{b}{f})$ must be at least one-third $\frac{\lambda}{\epsilon}$, where ϵ is the diameter of the silver grain, λ the wave-length (mean) of the light used. For ordinary values of ϵ and λ this makes the ratio of aperture to focal length between one-thirtieth and one-fortieth. *See* papers, "Notes on Astronomical Spectroscopes," *Astrophysical Journal*, Vol. III., p. 189, March, 1896; and "On the Conditions of Maximum Efficiency in the Use of the Spectrograph," *ibid.*, Vol. III., p. 321, May, 1896.

† For this reason (as has also been pointed out by Harkness, *Astronomy and Astrophysics*, Vol. XI., p. 648), photographs of nebulæ with different instruments may present a very different appearance, owing to the possible great difference in the number of superposed and surrounding stars. Too great caution cannot be exercised in guarding against hasty conclusions based on such comparisons.

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perceptible means of propulsion. Having, apparently, anticipated the latest discovery of naval mechanics, he propels his vessel by means of a jet of water violently driven out of the stern; as the water, however, has to be drawn in again by the same vent (the rectum), his journeys by this method are not very long, and are somewhat spasmodic. This drawing in and expelling of water through the rectum is the ordinary method of respiration also, which is effected chiefly under water, at least during the earlier larval stages; but the larva is also able to breathe atmospheric air in a way not yet fully understood, I believe, but which was to be expected in an insect whose later existence was to be spent in air—not in water. It may be noticed that as the time for the final change approaches, the nymph is fond of resting with either the extreme tip of the tail out of water, or else the head and one or both within, and forms with the two lateral ones a minute channel as large as a fine needle, which is always open—even when the spines appear to be quite closed—and this apparently also serves as a spiracle. In several of the figures (*e.g.*, Figs. 3, 4, and 5) white threads are seen proceeding from the split nymph skin. These are the tracheæ, which connect with the pair of spiracles already referred to, and are ruptured as the imago comes out. They easily locate the position of the spiracles in the dry nymph skin, if any difficulty is experienced in finding them from the outside.

Fig. 1.—Larva of Dragon Fly. Mask extended.

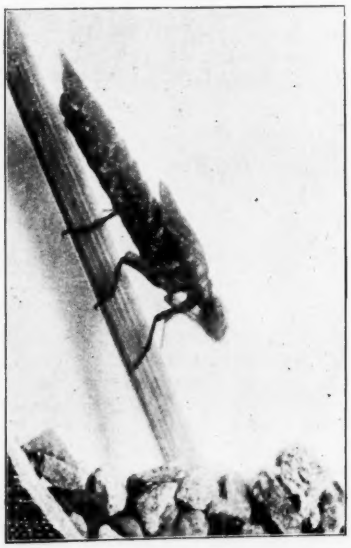

Fig. 2.—Larva of the Dragon Fly.

When full fed the dull brown eyes of the larva become brilliant green, being indeed the colour of the perfect eyes within; the larva then crawls laboriously up some stick or water plant, the body close pressed against the stem, and assisted by the scales and spines of the abdomen—not disdaining the friendly help of a pencil if such be forth-

Fig. 3.

Fig. 4.

Fig. 5

The Metamorphosis of the Dragon Fly: "Slowly the body emerges." Photographed from Life.

shoulders (if they may so be called). Now if a dry nymph skin be examined, two spiracles like horny lips will be found, one on each side, behind the head, placed vertically in the fold between the segments bearing the first and second pair of legs, and these spiracles in the living larva may be noticed open when above water; and, again, of the three spines closing the rectum, the two lateral ones are sharp, but the third is cut off at the point and grooved

coming, and trying apparently, with vigorous switchings of the abdomen, the stability of its chosen support.

After about ten minutes to half an hour of drying, the part immediately behind the eyes and above the wing cases swells, cracks, and opens, and discloses the bright green body of the perfect insect. Slowly the body emerges; the brown cases of the eyes are thrust farther and farther aside, and the enormous head with its compound eyes protrudes

fully out; at the same time the little crumpled wings are drawn out of their cases, then the legs one by one, the imago now hanging with head bent right back and the wings pointing upwards, the whole insect hanging, with six segments of the abdomen exposed, wet and limp from the dry nymph skin, still clinging firmly to its support by its stiff and empty legs. (*See* Figs. 3, 4, and 5.)

After hanging like this for some ten minutes or more, until the legs are strong enough, the insect, by a quick contraction of the body, suddenly lifts its head, and seizing with all six legs the dry nymph skin, quickly withdraws the remaining four segments of the abdomen out of its sheath, and hangs by its legs alone (Fig. 6). The wings now hang down and begin slowly to expand, at first dull and mealy-looking; as they lengthen they get flatter and clearer, until in about half an hour they show all the beauty of their gauzy texture. They are still, however, very pale green and soft, and the body of the insect is still wet and limp; but as the fluid which fills the animal is exuded drop by drop, the body stiffens and darkens, the wings dry, and are raised and then lowered to the position so well known. After about five hours from first emerging from the water, the perfect dragon fly is ready with quivering wings for its new life, often, alas! to be cut short within an hour by a hungry bird. It may seem incredible that birds should be able to catch so rapid a flier, but when first out the dragon fly is not so very rapid on the wing, and is, when fluttering or resting, a most conspicuous object. The poor ethereal *demoiselle*, almost before she has tasted the joys of her new and beautiful life, is snapped up by a vulgar sparrow.

The figures are life size, some of the emerging imago a trifle enlarged; they are taken from living specimens except Fig. 1, it being impossible to photograph the extended mask from life.

Fig. 6.

Fig. 7.

Fig. 8.

The Dragon Fly emerged and hanging on the Nymph Skin; the Body stiffens and darkens, and the Wings slowly expand. Photographed from Life.

THE MINISTRY OF LEAVES.

By Rev. Alex. S. Wilson, M.A., B.Sc.

THE colours of the two great kingdoms of organic nature present a striking contrast; as a whole the colours of animals are characterized by variety, those of plants by uniformity. Blossoms, indeed, vie with insects and birds in the brilliancy and diversity of their tints, but the higher plants alone bear coloured blossoms, and these are few in comparison with the leaves. Although leaves present every diversity of shape, they are, for the most part, of one colour, and this uniformity is determined by the function they perform in the economy of nature.

Foliage owes its greenness, as is well known, to the presence in the cellules of the leaf of a colouring matter called chlorophyll, occurring in the form of little rounded particles. In the life of plants chlorophyll plays a *rôle* of highest importance.

The action of plants on the atmosphere was first convincingly proved by Dr. Priestley, the discoverer of oxygen. He placed a mouse in an air-tight glass jar, and, of course, found that after a time the mouse died, having exhausted the air contained in the jar. By repeated trials he ascertained how long the quantity of air which the jar held was capable of supporting the respiration of a mouse. The jar was then charged with fresh air; a living mouse, together with a growing plant, were introduced into it, and the whole exposed to sunlight. In this instance the mouse did not die when the usual time had elapsed, but continued to live as long as Dr. Priestley cared to prolong the experiment. In this way he satisfied himself that plants possess the power of regenerating vitiated air which has become unfit for animals to breathe, owing to the preponderance of carbonic acid.

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Carbonic acid is a compound of carbon and oxygen: under the influence of sunlight chlorophyll has the property of absorbing and decomposing this gas; the combination is broken up, the oxygen is returned to the air, and the carbon, retained by the chlorophyll, is employed in the building up of vegetable tissue. Carbon separated from the air in this way constitutes the most important part of the food of plants. In the dark, plants are incapable of extracting carbon from the air; they are dependent on light, which acts as a reducing agent on the carbonic acid absorbed by the leaves.

After it has been blown through among leaves, air is found on analysis to contain less carbonic acid and more oxygen than it did before. A few minutes' contact with the leaves of the vine is sufficient to deprive air entirely of its carbonic acid. If a bunch of mint be placed under water on which the sunlight is playing, bubbles of gas are seen to escape from the leaves, which, on examination, proves to be pure oxygen. Such facts sufficiently explain Dr. Priestley's results; the leaves of the plant absorbed the carbonic acid as fast as it was exhaled by the mouse, and substituted an equal volume of free oxygen, so that the composition of the air in the jar remained throughout the same as it was at first.

Animals, it thus appears, are indebted to vegetables, not merely for food, but likewise to a great extent for the air they breathe. "The oxygen we are breathing," wrote the late Prof. George Wilson, "was distilled for us some time ago by the magnolias of the Susquehanna and the great trees that skirt the Orinoco and the Amazon. The giant rhododendrons of the Himalayas contributed to it, the roses and myrtles of Cashmere, the cinnamon trees of Ceylon, and forests older than the flood buried deep in the heart of Africa, far behind the Mountains of the Moon." The relationship is, however, one of mutual dependence and benefit, for animals feed plants with carbon, and that in a gaseous combination suited to their powers of assimilation. The mouse in Dr. Priestley's experiment supplied the plant with both carbon and oxygen, but only received back the oxygen; this unequal exchange in the long run would necessarily mean the gradual transference of all the animal's substance to the tissues of the plant. This is, indeed, the ultimate destiny of all animal substance, for not only are vegetables the natural heirs of effete and refuse animal matter, but the carbon atoms of which any plant is built up, we may safely say, have all at one time or other formed part of some animal. Since plants are constantly receiving carbon from animals, the latter must refund their losses if their existence is to continue. To counterbalance its loss we must imagine the mouse in the experiment to devour a portion of the plant containing as much carbon as was eliminated in respiration. Even when accounts are thus squared, animals are still indebted to plants for the energy generated by the combustion of their food.

In the body of an animal there is always going on a process of slow combustion; oxygen taken in by the lungs enters into union with carbon derived from the food, carbonic acid is formed, and heat evolved. Every atom of carbon disengaged from oxygen by the plant represents an expenditure of heat upon the leaves equal to that developed during its combination with oxygen in the animal system. In the leaves this heat disappears; it becomes latent, and is stored up as potential energy. When we burn a piece of wood, not only is the carbon which the tree originally extracted from the air restored to the atmosphere in the form of carbonic acid, but the heat given out by the burning wood corresponds exactly to the amount by which the sunbeams were chilled through the activity of the leaves while the wood was growing. Robbing the sunshine of its heat in this way, leaves must act as refrigerators; leaves exert a further cooling influence on account of the watery vapour they are constantly giving off, for whenever water evaporates much heat is rendered latent, and ceases to be discerned by the senses.

A man is said to exhale about one hundred gallons of carbonic acid in a day. Boussingault estimated that a square yard of leaf surface, reckoning both the upper and lower sides of the leaves, can under favourable circumstances decompose rather more than a gallon of carbonic acid in a day. At this rate, one hundred square yards of leaf surface should keep a man going with oxygen. A single tree would suffice for quite a number of people, for according to the late Prof. Asa Gray's computation, even a moderately sized elm possesses five acres of leaf surface.

Widely as they differ in appearance, a lung and a leaf are constructed on very similar principles. In the lungs the air tubes are subdivided into an infinite number of small ramifications, around which the blood-vessels are distributed in an extremely fine network. By this arrangement an immense surface is exposed to the air, with comparatively small expenditure of space. Through the delicate membranous walls of these fine tubes the air penetrates into the blood-vessels beneath, and from the blood carbonic acid diffuses into the air tubes, and is exhaled. The typical leaf, again, is a thin expanded plate, offering a large surface to the air relatively to its mass; its lower stratum is honeycombed with innumerable air spaces and intercellular passages, which communicate with the external air through thousands of pores or stomata. Oxygen and carbonic acid are exchanged through the walls of the leaf-cells very much as in the lungs, but in the reverse order. The flattened form of the leaf secures illumination and promotes evaporation; lungs, having no need of light, are shaped to suit the space available. The resemblance between the submerged leaves of aquatic plants, such as the water-buttercup, and the external gills or branchiæ of the young tadpole and other amphibians, is particularly striking. Both organs are cut up into fine, thread-like segments, giving them a fringed or feather-like appearance; the large absorbing area thus presented to the water facilitates the absorption of the dissolved gases. Leaves are, however, organs of nutrition. This resemblance to respiratory organs arises entirely from the fact that by far the largest proportion of a plant's food is absorbed in the gaseous condition. Referring to this adaptation of the leaf, Johnstone, in his "Agricultural Chemistry," says: "How beautiful is the contrivance of the expanded leaf! The air contains only one gallon of carbonic acid in two thousand five hundred, and this proportion has been adjusted to the health and comfort of animals, to whom this gas is hurtful. But to catch this minute quantity, the tree hangs out thousands of square feet of leaf in perpetual motion, through an ever-moving air; and thus by the conjoined labours of millions of pores, the substance of whole forests of solid wood is slowly extracted from the fleeting winds."

Chlorophyll itself owes its formation to light; but to conceive how the ethereal undulations, acting on the living substance of a leaf-cell, can elaborate a structure so complex, baffles imagination. How marvellous are the properties of light and how manifold its adjustments to differently constituted materials! Light is at once the most useful of natural agencies and the most beautiful of physical phenomena. And yet it must be tempered to our vision. Painful and blinding the glare from rock or

desert, but what more grateful than the sight of fresh green meadows! In contact with the grass light is purified from rays which fatigue and injure our eyes. This tempering of the sunshine is another of the many benefactions we owe to the ministry of leaves.

THE FACE OF THE SKY FOR AUGUST.

By HERBERT SADLER, F.R.A.S.

CONVENIENTLY observable minima of Algol occur at 0h. 36m. A.M. on the **18th**, and 9h. 25m. P.M. on the **21st**.

Mercury is too near the Sun to be conveniently observed during August.

Venus, as a morning star, is very well situated for observation. She rises on the **1st** at 1h. A.M., or three and a half hours before the Sun, with a northern declination at noon of 20° 52′, and an apparent diameter of 18½″, about $\frac{455}{1000}$ths of the disc being illuminated. On the **9th** she rises at 1h. 3m. A.M., with a northern declination of 21° 19′, and an apparent diameter of 17½″. On the **19th** she rises at 1h. 13m. A.M., with a northern declination of 21° 18′, and an apparent diameter of 16¼″, about $\frac{555}{1000}$ths of the disc being illuminated. On the **31st** she rises at about 1h. 30m. A.M., with a northern declination of 19° 40′, and an apparent diameter of 15″. During August she describes a direct path through the whole of Gemini, on the borders of which constellation and Cancer she is placed at the end of the month.

Both Mars and Jupiter are invisible, being too near the Sun to be observed to any advantage by the amateur.

Saturn is an evening star, but should be looked for as soon after sunset as possible; besides, his low declination interferes with the accurate observation of delicate details. On the **1st** he sets at about 11h. 20m. P.M., with a southern declination of 16° 49′, and an apparent equatorial diameter of 17″ (the major axis of the ring system being 40″ in diameter, and the minor 16″). On the **10th** he sets at 10h. 46m. P.M., with a southern declination of 16° 54′, and an apparent equatorial diameter of 16½″. On the **20th** he sets at 10h. 8m. P.M., with a southern declination of 17° 1′, and an apparent equatorial diameter of 16¼″. On the **31st** he sets at 9h. 25m. P.M., or nearly two and three-quarter hours after the Sun, with a southern declination of 17° 10′, and an apparent equatorial diameter of 16¼″. He is in quadrature with the Sun on the **17th**. During August Saturn describes a short direct path in Libra.

Uranus is also an evening star, but, owing to his great southern declination, must be looked for as soon as possible after sunset to be caught at all. On the **1st** he sets at 11h. 10m. P.M., with a southern declination of 18° 55′, and an apparent diameter of 3·6″. On the **31st** he sets at 9h. 15m. P.M., with a southern declination of 18° 55′. He is stationary in Libra on the **3rd**, and afterwards describes a very short direct path in that constellation.

Neptune does not rise until nearly 11h. P.M. at the end of the month, and we therefore defer an ephemeris of him until September.

This month is one of the most favourable ones in which to observe shooting stars. The most noted shower is that of the Permidæ, with a radiant point at the maximum display on the **10th** in R.A. 11h. 52m., N.D. 56°. Observations of this region with an opera-glass will, no doubt, show stationary meteors, or meteors which shift their positions very slowly. Their places, and the direction of their shift, should be noted for the purpose of determining whether the radiant is a geometrical point or a circle, or an elliptic area, as suggested with regard to the November meteors (*Monthly Notices of the Royal Astronomical Society*, Vol. XLVII., pp. 66-73). The radiant point sinks at 5h. 37m. A.M.

The Moon enters her first quarter at 6h. 25m. P.M. on the **5th**; is full at 2h. 23m. P.M. on the **12th**; enters her last quarter at 8h. 29m. A.M. on the **20th**; and is new at 3h. 29m. A.M. on the **28th**.

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

Communications for this column should be addressed, till further notice, to the Chess Editor, KNOWLEDGE, 326, High Holborn.

Solutions of July Problems.

No. 1.

(By W. Clugston.)

1. R to Kt6, and mates next move.

No. 2.

(By A. C. Challenger.)

Key-move.—1. Kt to K5.

If 1. . . . K × Kt, 2. Q to K4ch, etc.
1. . . . K to K6, 2. Kt to B4ch, etc.
1. . . . B × BP, 2. Kt × Bch, etc.
1. . . . KB moves, 2. Kt to B3ch, etc.

CORRECT SOLUTIONS of both problems received from H. S. Brandreth, Alpha.

Of No. 1 only from G. G. Beazley, W. H. Lunn, Kappa, H. W. Elcum, J. M'Robert,

Of No. 2 only from Capt. Forde.

H. D'O. Bernard.—The added Pawn is a happy idea, but we fear there is still a solution by 1. KKt5, K moves (best); 2. RR6, Pch; 3. KR5. If 1. . . . PR4, 2. KtB2 or 4. This illustrates that dread of the "many keys."

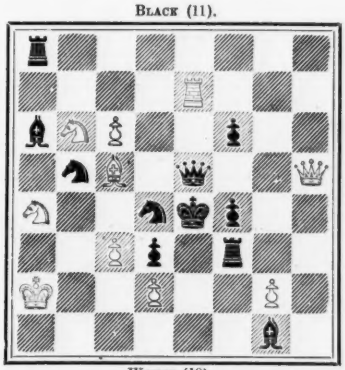
B. E. Errington.—In No. 1 (June Number), if 1. P × Kt, K moves, and there is no mate. The key, 1. QKt7, in this case allows the Pawn to mate by Queening, the Black Bishop being pinned.

PROBLEMS.

No. 1.

By J. T. Blakemore.

BLACK (11).



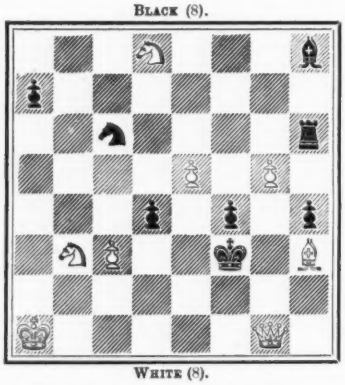
WHITE (10).

White mates in two moves.

No. 2.

By C. D. Locock.

BLACK (8).



WHITE (8).

White mates in three moves.

[The above is an alternative version of a recent tourney problem.]

CHESS INTELLIGENCE.

The Ladies' International Tournament came to a successful conclusion on July 3rd. Miss Rudge won the first prize without losing a single game, her one drawn game being of the nature of an accident. Her performance, and that of Miss Thorold, who was third, seems to show that the established provincial celebrities can still more than hold their own with the energetic members of the ladies' club in London. These latter have had all the advantage of excellent practice against many of the London clubs, but the majority apparently lacked that steadiness, born of experience, to which the West of England representatives owed their success. The following was the prize list :—

1. Miss Rudge, Bristol (£60) 18½
2. Mrs. Fagan, London (£50) 15½
3. Miss Thorold, Bath (£40) 14
4. Mrs. Worrall, America (£30) 13
5. Mrs. Bonnefin, London (£20) 12½
6. Lady Thomas and Mrs. Berry (equal)... 11½

After a succession of drawn games towards the close, M. Tchigorin won his match with M. Schiffers by 7 games to 1, with 6 draws. By a curious coincidence the ninth game of the match was identical for the first ten moves with the game (Locock *v.* Trenchard) recently published in this column. But M. Schiffers, who was playing White, overlooked the winning move, 11. Q to R5, and ultimately lost the game. M. Tchigorin has now defeated M. Schiffers in five matches out of six during the last twenty-four years, but in tournament play the result has been very different, so far as their personal encounters have been concerned.

The Chess Bouquet. By F. R. Gittins. (Feilden, McAllan, & Co.) This long-expected work has now made its appearance. The satisfactory result is a handsomely bound crown quarto volume of two hundred and sixty pages. The scope of the work is probably already known to many of our readers. Suffice it to say it contains the chess biographies of some seventy or eighty of the leading problem composers and chess editors of the United Kingdom, adorned with their portraits, and accompanied by their specially selected problems. There are also essays on problems and solving by Messrs. Laws, Hume, and others. The portraits have come out particularly well in almost every case ; while the problems, nearly seven hundred in number, form an unrivalled collection, representing as they do the cream of the productions of living British composers. Among others who have frequently contributed to this column we notice the biographies and compositions of Messrs. G. K. Ansell, J. T. Blakemore, A. C. Challenger, and A. G. Fellows ; the last named also contributes the dedicatory poem, and in other respects we believe has had some share in editing the work. Certainly it is a book to be bought and studied by all who take an interest in chess problems.

Chess Openings. By J. Mason. (Horace Cox & Co.) 2s. net. This is Mr. Mason's third treatise on the game, written in that semi-philosophic style (with traces of Carlylese) which the reader has now learnt to expect. It is a very useful and well-written book of one hundred and fourteen pages, the introduction on "development" being especially instructive. The analysis is on the "large-type main variation" plan, with subsidiary variations in smaller type. Though not perhaps so concise as the "column" system, this plan makes the book more readable, and not, we think, less easy for reference. Mr. Mason draws somewhat largely on his previous works, but the book is no worse for that. It is certainly the best of the smaller treatises on the openings.

KNOWLEDGE, PUBLISHED MONTHLY.

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PLATE.—The Hourglass Sea on Mars.

NOTICES.

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